The
# ENGINEERS' DIGEST

REVIEW OF [UNIVERSITY OF MICHIGAN] D ENGINEERING PROGRESS

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ENGINEERING

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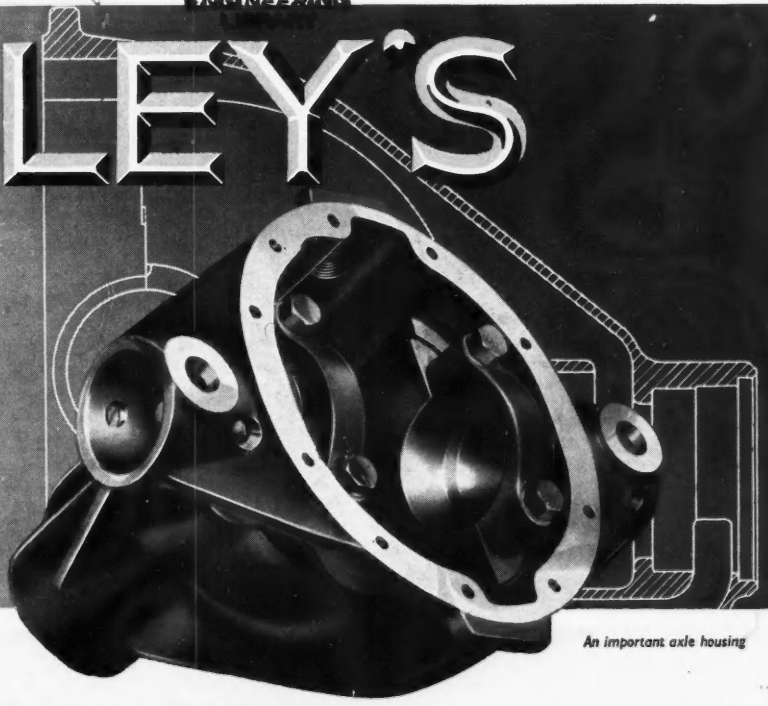

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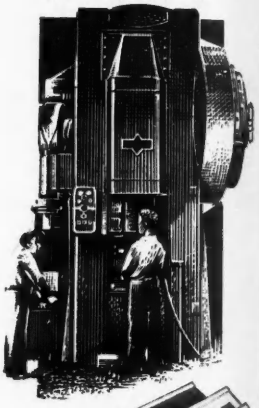

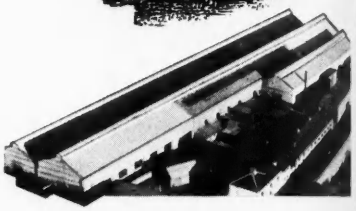

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# THE BLUE PAGES

## A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

### ● *CATHODIC PROTECTION OF GLASS-LINED WATER HEATERS*

In the course of an investigation of methods for protecting pipe lines from soil corrosion, it had been discovered that the cathodic protection of glass-coated pipe lines was much more effective than cathodic protection of bare pipe or of pipe coated with organic materials. The principle of combining cathodic protection with a glass coating to combat corrosion is, of course, applicable to many metallic structures which can be glass-coated. A particularly interesting recent example is the application of this principle to glass-lined water heaters. In the past it had been assumed that in order to give the desired result, the glass coating had to be totally continuous. No defects could be permitted because the glass coating was the only protection against corrosion of the tank. This fundamental concept of coverage obviously calls for expensive features of construction. Thus, thermal stresses, sharp edges, weld beads and sharp corners must be avoided, and careful inspection of every part of the lining is required. Moreover, the use of enamelling grade iron sheet is required because of the importance of avoiding glass coating defects and defects resulting from a poor sheet surface. A recent report describes the results obtained with both glass-lined and galvanized gas-fired water heaters, in which magnesium anodes were installed for corrosion protection. From the data collected it was concluded that magnesium anodes offered complete protection to glass-lined water heaters in all types of waters encountered, while magnesium anodes are not effective in galvanized heaters where the dissolved solid contents of the water are below 120 parts per million, that is, in the case of soft, low-conductivity water.

### ● *COPPER-CLAD ALUMINIUM*

Copper-clad aluminium has been used for electrical applications for many years, but its possibilities in other fields are only now beginning to be appreciated. Copper can be bonded to aluminium by a combined welding and hot-rolling process, but the production of a satisfactory composite metal requires careful control. Copper-clad aluminium is manufactured with copper on one or both sides, with the copper thickness ranging from 5 to 50 per cent of the total thickness. The minimum amount of copper for a given overall thickness will best be determined by studying the purpose for which the material is required. Where an impervious layer of copper free of pinholes is required, a minimum thickness of the copper of 0·001 inch is recommended; but where the copper is employed merely for ease of soldering and an occasional pinhole is not objectionable, thinner layers may be used. The coefficients of thermal expansion and the moduli of elasticity of the composite metals are quite close to those of aluminium. In general, the mechanical properties resemble those of aluminium more closely than those of copper. The possibilities of corrosion-couples or galvanic action must not be overlooked, and for use in some environments it would be necessary to protect the cut edges of the sheet to prevent such effects. Since a brittle copper-aluminium compound can form on melting, welding requires considerable care. However, satisfactory joints can be made by spot welding of single-clad material if the aluminium surfaces are placed in contact with each other. Soft soldering of the copper layer offers no problem.

### ● *ARC WELDING PROGRESS*

A recent report gives important information on the characteristics of thoriated tungsten electrodes which were recently introduced into practice together with the direct current method of welding aluminium by the tungsten-arc process. Unlike the conventional tungsten electrode, the thoriated electrode produces a much smoother striking arc, and touch starting can be accomplished with less tendency of the electrode to stick, and with no noisy arc sputtering. The tip of the thoriated electrode will not be as brilliant and the end will not be molten, as is the case with the plain tungsten electrode. As welding is continued, there will be less tendency for the electrode to be contaminated by the molten weld metal when the electrode accidentally touches the workpiece, and it will not be necessary to stop welding to grind or break off a length of the contaminated section. Thus, a higher production rate can be achieved and much less electrode material is used than is the case with a pure tungsten electrode. Also, the use of thoriated electrodes results in a reduced arc voltage, and the beneficial effects of the reduced cathode voltage drop are less radiated heat and less heat absorbed by the electrode holder. All the laboratory and production tests reported were made with electrodes containing a thoria content of one per cent. The use of the new

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electrode type is neither essential for welding aluminium nor is it limited to that material. In fact, its advantages apply equally to all direct-current straight-polarity, inert-gas shielded tungsten-arc welding, including stainless steel, copper, carbon steel, titanium and other metals.

### ● *NOVEL FATIGUE TEST*

The development of a new test procedure has been announced which is claimed to permit the rapid determination of the endurance limit of metals and plastics and will therefore be of considerable help in speeding up the development of new materials. It is stated that by the new test a complete endurance limit investigation can be completed in ten hours or less, as compared with a time of three months required with conventional fatigue testing equipment. The method evolved requires the selection of identical specimens of the material to be tested and putting them under stress in a definite range. The specimens are then subjected to an equal number of cycles of vibration so that all specimens will be on an even level of fatigue. This vibration test will take a few hours only. After this test the specimens are placed in the new apparatus and subjected to controlled temperatures ranging from 20° C to 100° C. The specimens all have the same length, about 2 in., at the beginning of this heating test, but it has been found that as each specimen is subjected to a higher temperature, its length changes in proportion to the amount of stress to which the particular specimen had been previously subjected. The apparatus automatically magnifies the amount of the resultant expansion 3500 times and records it. In approximately two hours the total linear expansion of all test specimens has been recorded. When these values are plotted against the stresses previously applied to the specimens, a sharp dip in the resulting curve appears at the point where the test material reaches its endurance limit.

### ● *NOVEL PRESSURE CHARGER FOR DIESELS*

Recent developments in diesel engine design emphasize the importance of the exhaust gas turbine driven pressure charger as outstanding means of increasing specific engine power. The announcement of a novel design of exhaust gas turbine and blower unit therefore deserves the greatest attention. Apart from the fact that the design of the exhaust gas turbine is based upon experiences gained with the operation of explosion type gas turbines, the arrangement of the exhaust gas supply to the turbine nozzles is of outstanding interest. It was found that the size and length of the connections between the engine exhaust valves and the nozzle chest, and also the size of the latter, exert an important influence upon pressure drop and heat drop and should therefore be kept to a minimum in order to utilise the impulse energy of the discharged exhaust gases. In order to meet this requirement, the new exhaust gas turbine was so designed that the exhaust gases from each cylinder are led through short connecting pipes to individual nozzle chambers. For this purpose, a gas turbine of the vertical shaft type is placed directly above the engine cylinder heads, and in the case of a V-type engine, between the two rows of exhaust valves, the turbo-blower forming the upper part of the unit. As gas temperature drop between engine and turbine is thus kept to a minimum, provision for cooling the roots of the gas turbine blades had to be made. The lower end of the turbine shaft is therefore made hollow so that cooling water can reach the blade roots through internal passages.

### ● *COMPRESSED AIR ARC TORCH*

A compact electric arc and compressed air gouging and cutting torch is claimed to be capable of cutting austenitic chrome-nickel weld metal at speeds comparable to the oxygen-acetylene torch and at a fraction of the cost. The torch uses a $\frac{3}{8} \times 12$ inch carbon electrode requiring a current of 300 to 400 amps. In the rotating nozzle which holds the electrode, two $\frac{1}{4}$ inch holes are provided which constitute the compressed air outlets. The escaping air stream therefore passes parallel with the carbon electrode. The new torch is the outcome of efforts to speed up the gouging of austenitic chrome-nickel weld metal seams in naval armour plate. Gouging or cutting with ordinary methods is out of the question and the removal of such welds is slow and costly. Chipping is difficult because of the work-hardening properties of the metal. This led to melting it out with the electric arc. At first, gravity was depended upon to remove the molten metal. As a next step an intermittent air jet was used to blow out the molten metal. Later, it was found possible to maintain the arc in a continuous stream of air parallel with the plate. The first combined air-arc torch removed 2400 ft of $\frac{3}{8}$ inch austenitic fillet weld in 20 man-days, while removal by chipping would have taken at least 120 man-days. The torch is finding wide application in structural fabrication, foundries, and steel mills. Although originally developed for stainless steel, it is equally useful for similar work on mild steel.

### ● *CATALYST IN ENGINE CYLINDER*

The history of the development of the internal combustion engine bears witness to the establishment of numerous theories concerning the possible suppression of carbon formation in the engine cylinder and the improvement of engine efficiency. Some of these proposals have been developed with success, as, for instance, changing the structure of the fuel, improving engine design, introducing fuel additives such as tetraethyl lead, while other

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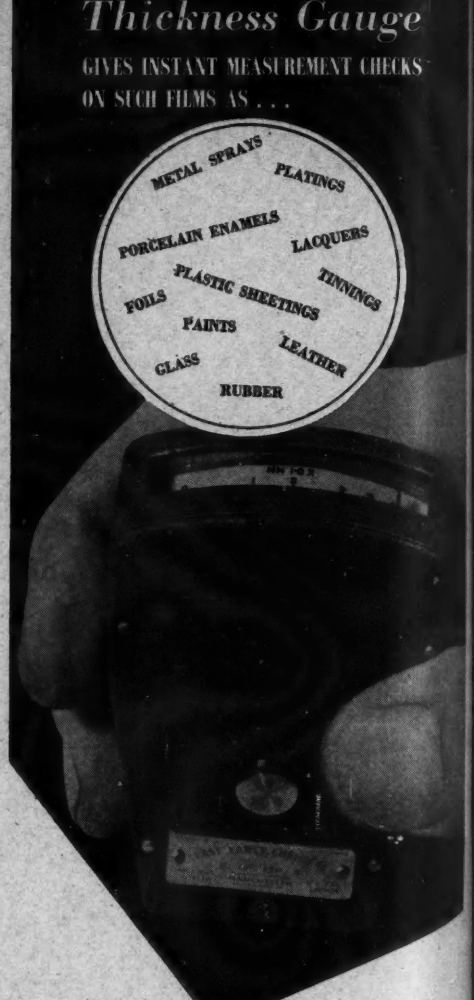


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suggestions have been notable failures. The latest suggestion, which is perhaps the most revolutionary proposal ever made, is to place a catalyst in the combustion space. This proposal is based upon the theory that differences in crude oil structures are the result of varying catalytic actions of mineral substances in the earth's structure. The catalytic substance to be incorporated in the engine cylinder is described as a conglomerate of a considerable number of minerals, mostly silicates and oxides, the exact nature of which is not revealed. Tests are reported to have shown an improvement as high as 25 octane numbers in the case of petrol, that is to say, a fuel with an octane number of 76 will perform as if it were rated as 100 octane, and it is considered that engines with a compression ratio of 10 to 1 may therefore become a practical proposition. It is stated that the catalyst is contained in a circular casting of light alloy with the minerals permanently fixed into some 18 perforations of the block. This block could be cast as part of the combustion chamber, but its installation for best performance has yet to be determined. The cost of the catalyst is said to be a matter of shillings; however, no information on the service life of the substance is given.

### ● *METAL PLATING OF POWDERS*

An ingenious plating process has been evolved which makes it possible to provide powders of minute particle size with a continuous metallic coating. The basic principle of the process consists in allowing the particles to be coated to drop through a metallic vapour produced in an evacuated vessel. The coating process will then take place automatically by condensation of metal vapour upon the particle surface. A typical apparatus employed for the purpose consists of a vertical chamber, capable of being evacuated, which in its lower part contains a centrally placed crucible for the reception of the metal to be used as coating material. The crucible is heated by a high-frequency induction coil surrounding it. An annular trough in the upper part of the vessel contains the powder to be coated, as, for instance, mica particles of 0·5 to 5 microns size. By mechanically vibrating the trough, a cloud of mica powder descends in the vessel, and by passing through the metal vapour, which, for instance, may be aluminium vapour, each particle is coated with aluminium by condensation of aluminium vapour on its surface. The coated particles are then collected in a trough at the bottom. Powders coated with aluminium in this way are claimed to have a lustrous appearance and can be used for the preparation of aluminium paint. Gold-plated grains of silica can also be produced, providing a paint requiring far less metal for the covering of a given surface area than paint containing solid powder as pigment. Powders of the coated type may also be used in the preparation of printing ink, and the inventor also envisages the employment of coated powders in powder-metallurgical applications.

### ● *NEW PROCESS FOR PEAT UTILIZATION*

Recent reports concerning the successful operation of a British gas turbine of the closed-cycle type employing peat as fuel have drawn renewed attention to the potential value of peat as fuel for the purposes of power production. It is, therefore, particularly interesting to note the publication of a recent German report announcing the development of a radically novel process for the "upgrading" of peat. Instead of attempting to remove the water content of the peat by drying, the new German process rests upon the addition of still more water to the peat and then heating it under pressure to 200° C. At this temperature the colloidal matter is broken down and the solid constituents can thus be separated from the water by centrifuging or other mechanical means. As the hot water is recirculated and used again in the cycle, heat consumption is minimised. By further heating to 250 to 260° C, exothermic separation of carbon dioxide and water takes place and a peat-coal is formed which is claimed to have properties comparable to those of semi-bituminous coal. As the heat released at this stage is greater than the heat consumption in the first stage, by-product power can be generated. The peat coal can be used for coking purposes. But it is also possible to generate producer gas by heating the peat-water mixture further to 250 to 300° C. The efficiency of this process is given as 90 per cent and is therefore higher than that of the usual producer gas processes averaging some 80 per cent. By carrying the heating still higher to 300 to 325° C a gas mixture of high calorific value is produced, the main constituents being methane and ethane. This gas mixture is said to be suitable for addition to town's gas after its $CO_2$ content has been removed.

### ● *ELECTRONIC INDICATION OF MERCURY COLUMN HEIGHT*

Differences in the height of two mercury columns of a mercury thermometer, and thus of pressure, can be determined with an extremely high degree of precision by a recently developed electronic method. Based on the use of high-frequency mutual-inductance probes, the method makes it possible to detect changes in the height of the mercury level of as little as 0·0005 inch. The method has also the advantage that direct visual observation of the mercury surfaces is not required. The mercury columns need not therefore have transparent windows, and readings can be made at a distance. Moreover, as no float or electric contact is required, disturbances of the mercury surface are minimized. Above the mercury surface of each column, a mutual-inductance

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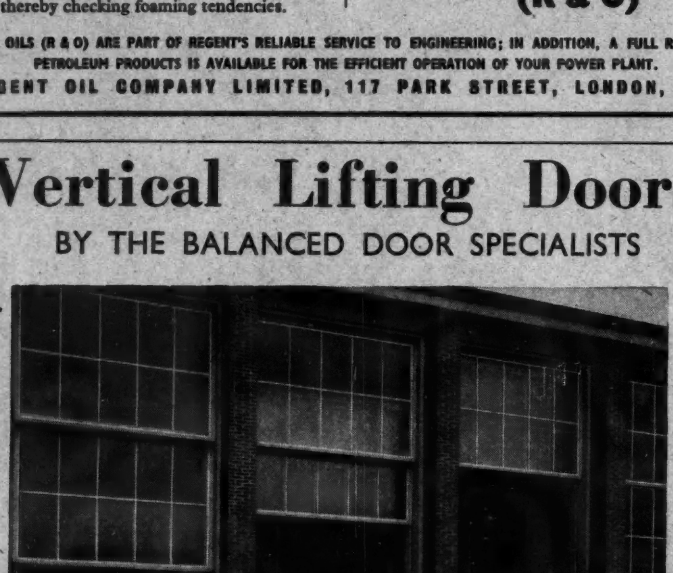

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probe comprising a primary and a secondary coil is mounted. When the primary coil is supplied with constant radio-frequency current, the voltage induced in the secondary coil varies with the mutual inductance, or coupling, between the two coils. The mutual inductance, in turn, varies with the proximity of the mercury surface; the closer the mercury surface is to the coils, the greater is its shielding effect, and the less the output voltage. The latter thus furnishes an index of the distance between the coils and the mercury surface and can be used to indicate this distance with a high degree of precision. In a typical instrument of this type, the coils are excited with a frequency of 480 kilocycles, and a vibrating relay compares the outputs of the coils of the two columns. The difference in the outputs is amplified and used for differential height indication.

### ● *ULTRASONIC SALVAGING METHOD*

There is no doubt that a much larger volume of scarce materials could be recovered if suitable salvaging methods were available, and this applies in particular to the small parts of tungsten and similar metals contained in thermionic valves. It is therefore significant that an American firm of valve manufacturers has succeeded in finding a method for salvaging such parts in a simple and inexpensive way. The device employed for this purpose vibrates at ultrasonic frequency and literally shakes glass beads off tungsten rods salvaged from thermionic valves which have proved faulty during manufacture and which require reprocessing. It is claimed that the new device permits the removal of glass sealed to the tungsten rods ten times faster than was possible by methods previously used. The ultrasonic vibrator, which oscillates at a frequency of 27,000 cycles per second, sets up a kindred oscillation in the tungsten rod which throws off the glass " like a dog shaking off water." This effect is accomplished by " compressional wave energy " and utilises the same principle that makes it possible for a singer's high note to shatter a wine glass. It goes without saying that other glass-sealing alloys such as molybdenum and platinum can also be salvaged by the method. There exist without doubt a great many similar cases where ultrasonic vibrations could be used for salvaging operations.

### ● *MACHINE TOOL CONTROL BY PAPER TAPE*

In order to make machine tool operation independent of the control action of the individual operator, a special automatic tele-control system has been devised which will operate a machine tool from a remote control point, as, for instance, a works engineer's office. The new system is claimed to be especially suitable for mass production plants where long repetitive runs of metal-cutting operations have to be carried out. The new control system embodies a paper tape perforator, and a sensing element, which translates the tape message into electric impulses which, in turn, actuate selsyn motors which, like the hand of the operator, guide the machine tool into action. Perforations in the paper tape represent the essential dimensions shown on the drawing for the part to be machined. When the paper tape travels through the sensing element, electric contacts are made and broken through the holes in the tape, thus closing and opening electric circuits. This produces varying voltages which are utilised for accurately controlling movement of the cutting tool and the workpiece in the machine tool. Machining accuracy is claimed to be entirely unaffected. The only manual work required in attending the machine tool is loading and unloading the work. The tape can be punched out by a draughtsman who makes computations from a blue print. This is carried out by placing the drawing on a grid-like graph paper.

### ● *NEW TESTS FOR METAL SURFACES*

A new test has been developed for detecting the presence of oils, greases and fats on metal surfaces to be plated. Named the " atomizer test," the new method is claimed to be remarkable both for its simplicity and its superiority over previous tests. Briefly, a panel of metal to be tested is hung up dry, then bathed in a spray of distilled water from the atomizer, which is about two feet away. After some 30 to 45 seconds the spray is shut off and the panel inspected. Where no grease or oil is present, the fine droplets of water coalesce and form a smooth film, while the presence of oil or grease causes the droplets to stand out like tiny beads from the greasy surface. It was found that the atomizer test is 160 times more sensitive than the most common wetting test used to detect grease on metal after cleaning in an alkaline dip. In solvent cleaning, where the residual mixture of grease, oil, or fat is spread uniformly over the metal, the atomizer test proved ten times as sensitive. It is expected that the atomizer test will rapidly replace the older water-break test, which has been used by commercial electroplaters for many years. The waterbreak method involves dipping the panel to be tested in water and then examining the surface for the continuous film of water that indicates a clean piece of metal. It is reported that other methods for detecting grease, oil and fat on metal have been investigated, such as detecting the removal of radioactive carbon mixed with the grease with a Geiger counter and taking photos of a panel that has been made fluorescent.

***For further information on developments reviewed in THE BLUE PAGES, readers are invited to write to the Editor.***

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# THE ENGINEERS' DIGEST

**REVIEW OF WORLD ENGINEERING PROGRESS**

VOL. XIII. No. 4. APRIL, 1952


## *Increase in Steel Production*

It is estimated that world steel production has increased by 11 per cent, to 206 million tons in 1951, thus exceeding the 200 million ton mark for the first time in the industrial history of mankind. These estimates are given in the latest Monthly Statistical Bulletin of the British Iron and Steel Federation.

The United States remains in the front rank, naturally, not only as the largest individual producer, but also as the country showing the greatest absolute expansion, over 7 million tons, or 8 per cent. But even larger percentage increases occurred in other major producing countries, notably the Soviet Union, Western Germany, France, Japan and Belgium, totalling, between themselves, 9 million tons.

Of the 20 million tons increase in world steel production, compared with the 1950 total, these countries together thus accounted for more than 16 million tons. In the United Kingdom, however, output declined by 650,000 tons, owing to the drastic curtailment of scrap imports. Other factors, such as labour shortage and readjustments under nationalisation, must have also contributed to this, though the British Iron and Steel Federation's survey tactfully does not mention them.

The British steel industry made good use of stocks accumulated in previous years to offset, at least partly, the fall in scrap supplies. The decline was, however, aggravated by home scrap flowing in increased quantities to the iron foundries and in reduced quantities to the steel works. Despite the decline, however, the United Kingdom remained the third largest steel producer in the world, next to the United States and the Soviet Union.

At the end of last year, American steel production was running at 105 million tons, according to reliable American sources. But the total actually produced in 1951 was lower because of the smaller output in the earlier part of the year. The 105 million tons capacity will be exceeded this year, provided that the present unrest among the steelworkers has no unfavourable consequences.

In 1951, world production was 54 per cent, or 72 million tons, above the peak pre-war output in 1937. Output in the United States alone was nearly 90 per cent higher, because of their large reserve of idle capacity in existence pre-war and their unhampered expansion during the war years.

Among the larger and old-established steel producers, only the Russian expansion has come near to equalling that of the United States in percentage terms, although the smaller and newer industries, such as that of Canada, have shown percentage rate increases above that of the United States.

The Soviet Union and her Eastern European satellites produced 40 million tons of steel in 1951, compared with 56 million tons in the O.E.E.C. countries and 134 million tons in the N.A.T.O. countries, which include the United States and Canada.

The table below compares world production in 1937, 1950 and 1951. Estimates for 1951 have been made for countries where the final figures are not yet available; those for Russia and other Eastern European countries have been supplied from United Nations' Economic Commission for Europe sources.

WORLD STEEL PRODUCTION IN MILLIONS OF (LONG) TONS

| | 1937 | 1950 | 1951 |
|---|---|---|---|
| U.S.A. | 50·57 | 86·46 | 93·87 |
| U.S.S.R. | 17·54 | 27·16 | 30·80 |
| United Kingdom | 12·98 | 16·29 | 15·64 |
| Western Germany | 15·37 | 11·93 | 13·29 |
| France | 7·79 | 8·51 | 9·68 |
| Eastern Europe | 6·45 | 8·02 | 9·09 |
| Japan | 5·71 | 4·76 | 6·39 |
| Belgium | 3·80 | 3·72 | 4·92 |
| Canada | 1·40 | 3·02 | 3·19 |
| Luxembourg | 2·47 | 2·41 | 3·03 |
| Italy | 2·05 | 2·32 | 3·00 |
| Saar | 2·30 | 1·87 | 2·56 |
| India | 0·90 | 1·44 | 1·50 |
| Sweden | 1·09 | 1·42 | 1·48 |
| Finland, Yugoslavia, Spain | 0·39 | 1·32 | 1·36 |
| Australia | 1·10 | 1·25 | 1·44 |
| Austria | 0·64 | 0·93 | 1·01 |
| South Africa | 0·33 | 0·74 | 0·93 |
| Brazil | 0·08 | 0·78 | 0·80 |
| Netherlands | 0·06 | 0·48 | 0·54 |
| Mexico | 0·02 | 0·22 | 0·30 |
| Turkey | — | 0·09 | 0·13 |
| Norway | 0·06 | 0·07 | 0·08 |
| Other Countries | — | 0·42 | 0·62 |
| Total | 133·65 | 185·63 | 205·65 |

# Measurement of Small Electric Arc Voltages and Currents

By B. Novotny. (From *Elektrotechnicky Obzor*, Vol. 40, Nos. 15-18, pp. 304-310, 12 illustrations.)

## I. Measuring The Voltage

In investigating the characteristics of electric arcs it is necessary to measure or record voltages and currents which, in the course of a small fraction of a second, may change in order of magnitude. The conventional methods of oscillographic recording suffer from the drawback that, if the whole operation is to be recorded, the deflections of the beam for currents and voltages near zero—and these are the most important as concerns the formative stages and the later development of the arc—are so small that most details are lost and often not even the inception of the arc can be determined with certainty. This is the case, in particular, when the operating voltages are of a higher order, for instance of the order of 500V, as then the voltage across the contacts just opening may be as little as 2 per cent of the peak value. Fig. 1 shows an example of this. Here, the arc recurs at an instantaneous tension of 210V, but from the ordinary oscillograph it is impossible to determine whether the substantial reduction of the arc voltage which occurs in the third semi-cycle was due to contact bounce or to restriking of the arc.

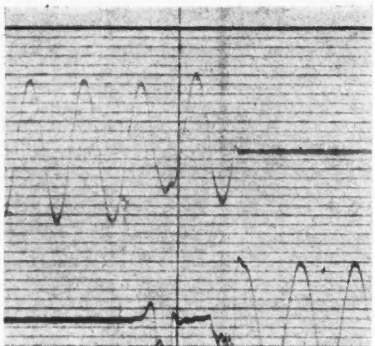


Fig. 1. **Normal oscillogram from a moving coil oscillograph showing the breaking of a current of 380 A at 210 V and a power factor of 0·5.**
The upper graph represents the current, the lower graph represents the voltage at the contacts of the circuit breaker.

To overcome this difficulty in measuring arc voltages, various devices can be used in conjunction with conventional oscillographs; they affect the linearity of the latter, and small voltages are amplified to a greater degree than higher voltages. A novel and simple device of this kind, based on the use of selenium rectifier cells, is described in the following and practical design data are given. It is called a "limiter" or "shunt" according to the function it is intended to fulfil.

Selenium rectifiers are commonly iron discs of 18 to 112 mm diameter, coated on one side with a selenium layer 0·05 to 0·1 mm thick; this, in turn, is covered by a layer usually of an alloy having a very low melting point which provides a contact surface. The high conductivity of the cell lies in the direction from the iron to this electrode. The cell, besides having unsymmetrical conductivity, has also the property that in the direction of conductivity, its resistance decreases very rapidly with increasing voltage; it is this latter property which is utilised in the "limiter." In addition, a current flowing in this direction does not produce the very appreciable heating that it would produce if it were to flow in the direction of high resistance. The selenium rectifier was chosen in preference to the copper-oxide rectifier because of its greater rate of decrease of resistance in the direction of conductivity with increasing voltage.

Fig. 2 shows the circuit diagram of the "limiter"; two selenium rectifiers $S_1$ and $S_2$ are connected in parallel but in opposite direction of conductivity; connected in parallel with them are a resistance $R_2$, and the measuring apparatus $MA$ together with a series resistance $R_3$, if required. The whole arrangement is connected in series with a resistance $R_1$. If $E$ is the voltage to be measured, the voltage $e_3$ across the terminals of the instrument can be expressed by:—

$$e_3 = R_a i_3 = \varphi(E) \quad .. \quad .. \quad (1)$$

where $R_a$ is the internal resistance of the instrument and $i_3$ the current flowing through it. $\varphi$ is the general function describing the relationship between $E$ and $e_3$. This, of course, is required to be non-linear and such that the higher voltages are more reduced than the lower values; taking into consideration the characteristics of the selenium rectifiers it can be shown that this condition is actually met by this circuit and that the corresponding function can be expressed thus:

$$E = e_3 \frac{R_a + R_3}{R_a} R_1 \left[ \frac{1}{R_a + R_3} + \frac{1}{R_2} + \frac{1}{R_1} + \frac{0{\cdot}152\,S}{n^{6{\cdot}09}} \left( \frac{R_a + R_3}{R_a} \right)^{5{\cdot}09} e_3^{5{\cdot}09} \right] \quad .. \quad (2)$$

where $S$ is the area of the rectifier element and $n$ the number of elements connected in series in each of the two rectifiers. This equation can be transformed and simplified for small and large values of $e_3$ respectively

$$e_3 = \frac{E\,R_a\,R_2}{R_1\,R_2 + (R_a + R_3)(R_1 + R_2)} \quad .. \quad (3a)$$

$$e_3 = \frac{n R_a^{6{\cdot}09}}{R_a + R_3} \sqrt{\frac{E}{0{\cdot}152\,S\,R_1}} \quad .. \quad (3b)$$

The change in direction of the characteristic begins near a value $e_{30}$, where

$$\frac{1}{R_a + R_3} + \frac{1}{R_2} + \frac{1}{R_1} = \frac{0{\cdot}152S}{n} \left( \frac{R_a + R_3}{R_a} \frac{e_{30}}{n} \right)^{5{\cdot}09} \quad (4)$$

For the function to be linear up to a value $e_3'$ it is

$$\left( \frac{e_{30}}{e_3'} \right)^{5{\cdot}09} = k \quad .. \quad .. \quad (5)$$

where $k$ is the ratio, on the one hand, of the conductivity of the resistances $R_2$ and $(R_a + R_3)$ and, on the

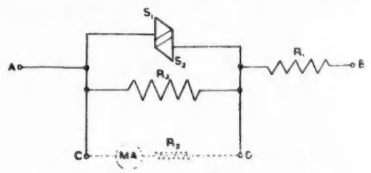



Fig. 2. **Schematic diagram of limiter.**
$S_1$ and $S_2$ are selenium rectifiers connected in parallel and in opposite direction of conductivity. $R_1$, $R_2$, and $R_3$ are ohmic resistances. $MA$ is the measuring instrument with resistance $R_a$.

other, the conductivity of the selenium rectifiers at $e_3'$; for an error of 10 per cent $k = 10$, and for an error of 1 per cent $k = 100$.

It is convenient to put

$$\frac{R_a + R_3}{R_a} \frac{e_3'}{n} = 0{\cdot}25\text{V} \qquad .. \qquad (6)$$

From this equation are determined the number $n$ of elements to be connected in series and the resistance $R_3$; $R_2$, $R_1$ and $S$ are determined from eq. (4) and $e_3$ and $E'$ from eq. (3a). $R_2$ is usually made infinite.

The following is a practical example of calculating a limiter for a moving coil oscillograph with an internal resistance $R_a = 50$ ohm; the conditions are that a voltage of 10V at the terminals of the circuit should produce 50mV at the terminals of the moving coil; and, further, that the characteristic of the measuring circuit should be linear up to 10V with a maximum error of 10 per cent at 10V. The maximum voltage of 500V at the terminals of the circuit is to be greatly suppressed.

According to eq. (6)

$$\frac{50 + R_3}{50} \frac{0{\cdot}05}{n} = 0{\cdot}25$$

Let $n = 1$, and $R_3 = 200$ according to eq. (5)

$$e_{30} = \sqrt[5{\cdot}09]{10} \times 0{\cdot}05 = 0{\cdot}0785\text{V}$$

and according to eqs. (4) and (3a)

$$\frac{1}{250} + \frac{1}{R_2} + \frac{1}{R_1} = 0{\cdot}152\ S\ (0{\cdot}393)^{5{\cdot}09} = 0{\cdot}0013\ S, \text{ and}$$

$$0{\cdot}05 = 10 \frac{50\ R_2}{R_1\ R_2 + 250\ (R_1 + R_2)}$$

With $R_2 = \infty$ :

$$0{\cdot}05 = 10 \frac{50}{R_1 + 250} \text{ and, consequently, } R_1 = 9750\ \Omega$$

$$S = \frac{1/250 + 1/9750}{0{\cdot}0013} = 3{\cdot}16\ \text{cm}^2\text{; this corresponds}$$

to a rectifier disc of 25 mm diameter.

The limiter will therefore consist of two discs of 25 mm diameter connected in parallel and in opposite direction of conductivity. Resistance $R_2$ will be omitted, resistances $R_1$ and $R_3$ will be 9750 $\Omega$ and 200 $\Omega$ respectively. The maximum consumption of this limiter at 500V will be 51·2 mA.

According to eq. (3b) the voltage at the terminals of the moving coil for a measuring voltage of 500 V will be

$$e_{3\,\max} = \frac{50}{250} \sqrt[6{\cdot}09]{\frac{500}{0{\cdot}152 \times 3{\cdot}16 \times 9750}} = 0{\cdot}1385\text{ V}$$

The voltage at the terminals of the limiter as a function of the measuring voltage is shown in Fig. 3.

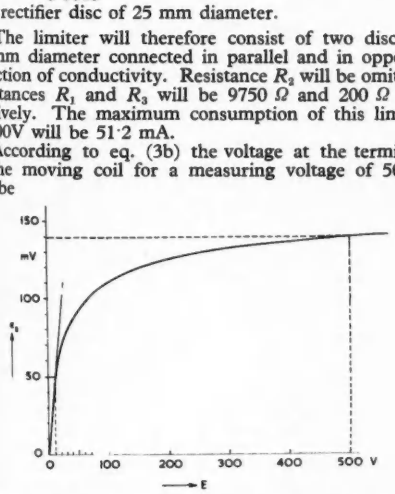



Fig. 3. **Characteristic of a limiter as shown in Fig. 2.** Selenium rectifier discs $S_1$ and $S_2$, 25 mm dia.; $R_1 = 9750\,\Omega$; $R_2 = \infty$; $R_3 = 200\ \Omega$; $MA$, moving coil oscillograph with internal resistance $R_a = 50\ \Omega$; $E$ is the voltage at the terminals $A$ and $B$; $e_3$ is the voltage at the terminals of the moving coil.

From the above example it will be seen that the selenium limiter has considerable possibilities for suppressing high measuring voltages; however, it has the disadvantage that, owing to its relatively large capacity, it can be used only with frequencies up to about 5 kcps. A practical example of the application of the limiter for measuring the arc voltage and current with a moving coil oscillograph is shown in Fig. 4; this shows the current and voltage on the interruption of a current of 680 A at 540 V and 0·55 power factor on one pole of a 3-phase circuit breaker.

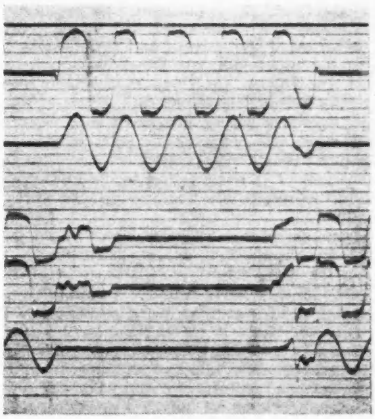



Fig. 4. **Oscillogram showing the breaking of a current of 680 A at 540 V and a power factor of 0·55.**
(*a*) Normal current oscillogram.
(*b*) Current oscillogram using limiter.
(*a′*) Normal voltage oscillogram.
(*b′*) Voltage oscillogram using medium-power limiter.
(*c′*) Voltage oscillogram using high-power limiter.

The current was measured by using an ohmic shunt, oscillogram (*a*), and a selenium limiter, oscillogram (*b*). The voltage was measured directly on the contacts, oscillogram (*a′*), over a limiter of low power, oscillogram (*b′*), and over a greatly suppressing limiter, oscillogram (*c′*). The calibration curves for the voltage oscillograms are shown in Fig. 5. From Fig. 4 it will be seen that oscillogram (*a′*) does not indicate any contact vibrations, nor the inception of the arc. The oscillogram (*b′*) already clearly shows contact vibration with 25 V and the inception of the arc 4 milliseconds before the voltage in oscillogram (*a′*) shows any tendency to rise. Oscillogram (*c′*) shows, on close scrutiny, ripples even in the apparently straight part of the zero line. These ripples have an amplitude of 0·1 mm corresponding to 0·32 V and indicate, in fact, the voltage drop between the contacts when they are closed.

## II. Measuring The Current

It has been shown that by measuring small voltages on the contacts of a circuit breaker, much can be learnt about the behaviour of the contacts themselves and about the early stages of the arc. Likewise, much can be learnt, from measuring small currents, about the extinguishing of the arc, the cooling of the hot gases, heating in the gap, and the possible restriking of the arc. The difficulty here is to devise equipment which would allow the detailed recording of currents, the intensity of which may range from milliamperes during the period of the cooling of the gases, to several thousands of amperes during short-circuit tests. The apparatus

designed to satisfy these conditions is also based on the selenium rectifier; it is somewhat different from the "limiter" already described and has been called a "selenium shunt."

In principle, the selenium shunt consists of two selenium rectifiers connected in parallel but in opposite direction of conductivity; an ohmic shunt can be connected in parallel with the two rectifiers.

The current to be measured flows through this arrangement and the voltage drop across the terminals of the rectifiers is applied to the oscillograph. The diagram of connections of the selenium shunt is very similar to that of the limiter shown in Fig. 2, as only resistance $R_1$ is omitted. The purpose of the selenium-rectifier in this shunt is as follows: at low current intensities, almost the whole current flows through the ohmic resistance $R_2$, as the resistance of the rectifiers in the direction of conductivity is relatively high. Therefore, for low intensities, the voltage drop is a linear function of the current and is determined by the value of the resistance $R_2$. When the intensity is increased, the voltage drop on $R_2$ and, therefore, the voltages on the terminals of the rectifiers $S_1$ and $S_2$ increase likewise. From a certain value onward, the rectifiers take over an increasing proportion of the current until the characteristic of the whole shunt becomes, for all practical purposes, identical with the characteristic of the selenium rectifier in the direction of conductivity.

The calculation of a selenium shunt by mathematical formulae is complicated, as its characteristic is non-linear for the high current intensities which may occur. These may be such as to produce a voltage drop of the order of up to 1 V per disc in the direction of conductivity when the shunt is under permanent load.

The shunts are, however, mainly used for measuring short-circuit currents and under similar conditions, and are therefore subject to high current intensities usually for short periods only. The maximum voltage drops admissible under these circumstances have been determined from experience. These are 1·2 V for a short-circuit current lasting 10 minutes; 1·8 V for a short-circuit current of 10 seconds, 3 V for one second, 5 V for 0·1 second and 13 V for 10 milliseconds.

From Fig. 2 it is not difficult to determine the number of discs to be connected in parallel, and the value of the resistance $R_2$; the highest sensitivity can, of course, be obtained by omitting resistance $R_2$. For the shunt the voltage on the terminals *CD* is a linear function of the current only over a smaller range than in the case of the voltage limiter. In this connection it may be useful to describe a shunt which has been developed for the study of short-circuit currents of short duration and up to 1000 A intensity. It consists of two selenium rectifiers, each made up of 80 discs of 45 mm diameter. These are connected in parallel, but in opposite direction of conductivity. The voltage on the terminals *CD* of the shunt can be applied to the moving coil of the oscillograph either through a series resistance, or over a separate voltage limiter. In the latter case, the low current intensities receive still more emphasis, so that currents of the order of several milliamperes can be observed at the same time as currents of several thousand amperes.

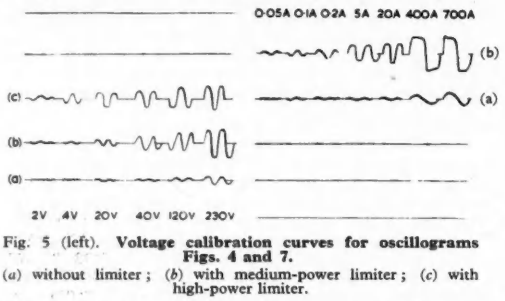



Fig. 5 (left). **Voltage calibration curves for oscillograms Figs. 4 and 7.**
(*a*) without limiter; (*b*) with medium-power limiter; (*c*) with high-power limiter.

Fig. 6 (right). **Current calibration curves for oscillogram Fig. 7.**
(*a*) With selenium shunt but without limiter.
(*b*) With selenium shunt and limiter.

Figs. 6 and 7 illustrate the advantages obtained by using selenium shunts for investigating the repeated restriking and extinguishing of arcs. The oscillograms of Fig. 6 were taken for calibration. Oscillogram (*b*) traces the voltage drop on the selenium shunt when a selenium limiter is connected in series with the moving coil; oscillogram (*a*) represents the same voltage drop if the selenium limiter is replaced by a series resistance. It will be seen that oscillogram (*a*) indicates currents of an intensity as low as 5 A, which is less than 1 per cent of the total current; however, with the same arrangement using a voltage limiter instead of the series resistance, clearly legible tracings can be obtained of currents of only 50 mA, oscillogram (*b*), which is less than 0·01 per cent of the maximum current.

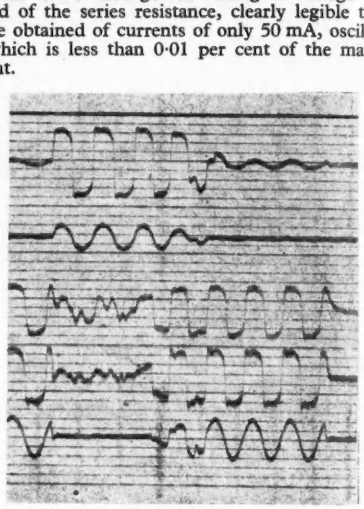



Fig. 7. **Oscillogram showing the breaking of a current of 680 A at 540 V and a power factor of 0·55.**
(*a*) Current oscillogram using selenium shunt only.
(*b*) Current oscillogram using selenium shunt and limiter.
(*a′*) Voltage oscillogram without limiter.
(*b′*) Voltage oscillogram with medium-power limiter.
(*c′*) Voltage oscillogram with high-power limiter.

Fig. 7 shows currents and voltages for one pole of a three-phase circuit breaker on making and breaking a circuit carrying 680 A at 540 V, and a power factor of 0·55. Although the directly connected moving coil of the oscillograph does not indicate any voltage for the period the contacts are closed, the same coil, connected through a voltage limiter, indicates a series of contact vibrations with arc voltages of up to 25 V, which allows the quality of the contact to be assessed at a glance.

From the oscillogram (*a*) it would seem that in the last negative half-wave there was a period lasting 4 milliseconds, during which there was no current flowing, and that after this the current increased to reach a maximum value of 150 A; it closed completely when again passing through zero at the end of the half-wave. From oscillogram (*b*), however, it will be seen that, in fact, during the 4-millisecond period the current was not zero, but about 15 A, rising subsequently to 150 A; and that after passing through zero into the positive half-cycle a small current of several milliamperes was flowing for 4 milliseconds, after which it rose sharply, reaching a value of 5 A when the voltage was about 750 V; and that it was only on the next passage through zero that the current eventually ceased.

# The Use of a Plastic Mass in Lathe Fixtures and Inspection Jigs

By R. K. Dooma and D. F. Gerasimov. (From *Stanki i Instrument*, No. 11, 1950, pp. 11-17 and No. 11, 1951, pp. 10-12, 23 illustrations.)

*Examples of lathe fixtures and inspection jigs using a plastic mass to transmit clamping pressure to an elastically deformed collet or mandrel member, or to a plunger member, are illustrated. The elastic analysis of free and stiffened thin cylindrical shells, as applied in such fixtures, is reviewed. Design and manufacturing recommendations are given. The composition of a suitable plastic mass and its processing are described.*

A plastic mass behaving somewhat like an incompressible liquid under the action of a plunger can be a useful component in jigs and fixtures. The mechanism is manipulated either by hand or operated by pneumatic or hydraulic action.

The lathe fixtures described here embody four types of clamping : (1) The clamping of components having a cylindrical hole by the expansion of an inner mandrel (Fig. 1) ; (2) the clamping of a component with an external cylindrical surface, by the contraction of an outer collet (Fig. 2) ; (3) the multi-point clamping of a component by means of a number of dog clamps (Fig. 3) and (4) the simultaneous clamping of a component by a mandrel or a collet and by a number of dog clamps. (Fig. 4).

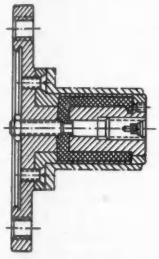


Fig. 1. **Mandrel fixture.**

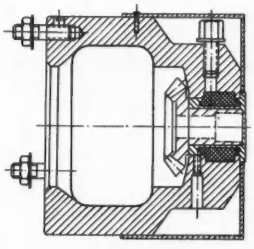


Fig. 2. **Collet fixture.**

Plastic mass is also used in inspection jigs. In Fig. 5 an inspection jig is shown, which serves for checking the concentricity of two internal bores. The jig swivels in the central hole of an inner mandrel member (1). The plastic mass (2), transmitting the pressure of the clamping screw (3) to the mandrel shell, centres the jig on the reference bore of the component. Swinging the indicator clock by means of knob (4) indicates the concentricity of the other cylindrical surfaces.

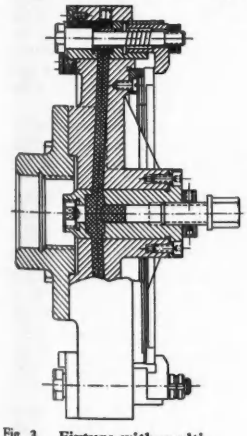


Fig. 3. **Fixture with multi-point clamping.**

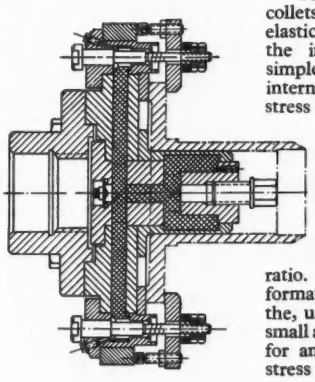


Fig. 4. **Fixture with mandrel and multi-point clamping.**

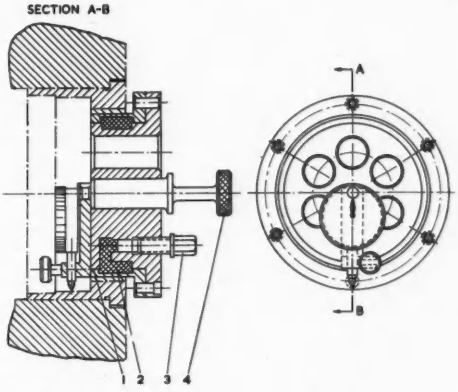



Fig. 5. **Inspection jig for checking concentricity of holes.**

In Fig. 6 an inspection jig is shown for the control of the distance between the centres of two machined holes in a casting. The casting is placed on the base of the jig and positioned by means of an internal member (1) expanded by means of plastic mass (2) under the pressure of the plunger (3) screwed in by hand. A loose indicating attachment swivelling in the tapered spigot hole in one of the flanged bushes (4) shows the error in the distance between the reference hole and the other holes.

Inspection of jigs of this type ensure an improved precision of dimensional control, due to the elimination of the unavoidable clearance between the reference hole of the component and a rigid positioning spigot.

To obtain proper functioning of inspection jigs of this type it is important to exercise great care in the design of the combination of mandrel and plunger mechanism.

The basic problem which confronts the designer of collets actuated by plastic mass is the analysis of the elastic deflections of a thin-walled cylindrical shell under the influence of internal or external pressure. A simple unconstrained thin cylinder, when subject to internal (or external) pressure $P$, develops a tangential stress

$$\sigma_1 = pR/h \quad .. \quad .. \quad (1)$$

and an axial stress

$$\sigma_2 = pR/(2h) \quad .. \quad .. \quad (2)$$

The radial deformation caused by these stresses is

$$\Delta R = R\,(\sigma_1 - \mu\,\sigma_2)/E \quad .. \quad (3)$$

where $E$ is Young's modulus, and $\mu$ is Poisson's ratio. Obviously, the axial stress $\sigma_2$ reduces the radial deformation, and it is therefore good practice to design the, usually annular, faces of the pressurized space as small as possible. Equation (2) must be suitably modified for an annular pressure space. In practice, the axial stress can be made insignificant. Then eq. (3) becomes

$$\Delta R = \frac{R}{E}\,\sigma_1 = \frac{pR^2}{Eh} = \frac{pR}{E\,(h/R)} \quad .. \quad (4)$$

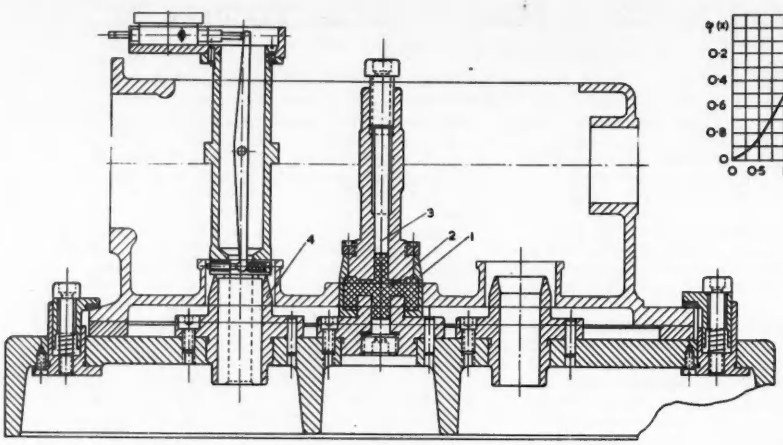



Fig. 6. **Inspection jig for checking the centre distance of holes.**

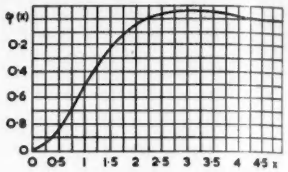



Fig. 8.

The last transformation of this expression shows that the radial deformation is directly proportional to the radius, and inversely proportional to the thickness/diameter ratio of the thin-walled cylinder. The maximum deformation is obtained at an allowable stress $\sigma_{al} = \sigma_y/k$, where $\sigma_y$ is the yield stress. A safety factor $k$ of 1·2 to 1·5 is recommended. Obviously the maximum increase in diameter is given by the following expression

$$\Delta D_{al} = \frac{\sigma_{al}}{E} D \qquad .. \qquad .. \qquad (5)$$

Experiments have shown that the maximum allowable pressure in the plastic mass depends upon the fit which closes the space filled with the mass. At a pressure of 200 kg/cm², plastic mass will leak through a clearance of 0·03 mm. At a pressure of 300 kg/cm² it will leak through a clearance of 0·02 mm.

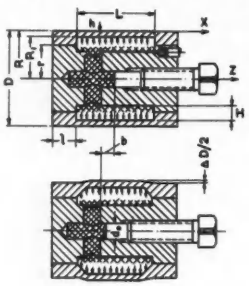



Fig. 7.

In practice, collets are normally designed with stiffening collars at both ends of the thin-walled cylinder, Fig. 7. Such stiffening rings interfere with the free deflection of the thin-walled cylinder and introduce local bending stresses in the neighbourhood of the stiffening rings. When the length of the thin-walled shell is sufficient, the following expression can be employed for the deflection

$$\Delta R = \frac{pR^2}{Eh} - \frac{pR^2}{Eh} \varphi(x) \qquad .. \qquad (6)$$

The second term in the above expression gives the influence of the stiffening collars. The function $\varphi(x)$ is reproduced in Fig. 8. The non-dimensional co-ordinate $x$ is related to the geometrical co-ordinate $z$.

$$x = \sqrt[4]{3(1-\mu^2)}\, z/\sqrt{Rh} = 1{\cdot}28 z/\sqrt{Rh} \qquad .. \quad (7)$$

From these expressions and the graph we deduce that at a distance $z = 1{\cdot}85\, R\sqrt{h/R}$ the influence of the stiffening ring vanishes, and hence the centre of the thin-walled cylinder is only affected by the end stiffening when the length of the cylinder is below the value $L < 3{\cdot}7\, R\sqrt{h/R}$. A thin-walled cylinder, the length of which exceeds this value, can be computed by means of the simple formula (4). For shorter thin-walled portions, stiffening must be taken into account, and the maximum deformation which occurs in the middle will be given by the expression

$$\Delta R = \frac{pR^2}{Eh} [1 - \varphi(x_{L/2})] \qquad .. \qquad .. \quad (8)$$

In choosing the wall thickness of the shell we have to consider the following requirements. Firstly, the shell must possess sufficient elastic deformation to exceed the maximum clearance between the component and the mandrel, to ensure reliable clamping. Secondly, the mandrel must be safe against failure by rupture or by plastic deformation.

In Table I, general formulae are given for the wall thickness of the thin-walled part of the mandrel in relation to the diameter and the length of this portion. The formula for wall thickness in the range of diameters 50-150 mm was determined from eqs. (4) and (8) and the assumed pressure of 300 kg/cm², which experience shows to be a suitable choice. On the other hand, in the range of 10-50 mm, it is possible to use a higher pressure. In this range the stresses generated by the interference fit between the stiffening rings and the inner member of the mandrel assembly resist the axial stresses produced by the hydrostatic pressure on the annular faces of the pressure space. This will prevent an axial displacement between the stiffening ring and the inner member and enable a very tight closure of the pressure space to be ensured, and thus make higher pressures possible.

Figures 9 and 10 illustrate the assumed hydrostatic pressures required to achieve the allowable increase in diameter with a wall thickness determined from the set of formulae of Table I.

TABLE I.

| Length of thin-walled cylindrical shell | Formula for the wall thickness of the shell | |
|---|---|---|
| | 10-50 mm dia. | 50-150 mm dia. |
| $L > R$ | $h = 0{\cdot}015\, D + 0{\cdot}5$ | $h = 0{\cdot}025\, D$ |
| $R > L > \frac{1}{2} R$ | $h = 0{\cdot}01\, D + 0{\cdot}5$ | $h = 0{\cdot}02\, D$ |
| $\frac{1}{2} R > L > \frac{1}{4} R$ | $h = 0{\cdot}01\, D + 0{\cdot}25$ | $h = 0{\cdot}015\, D$ |

All dimensions in millimetres.

Beyond a mandrel diameter of 150 mm we have to use the expressions developed earlier. Solving eq. (8) for the wall thickness $h$, and introducing eq. (5), we

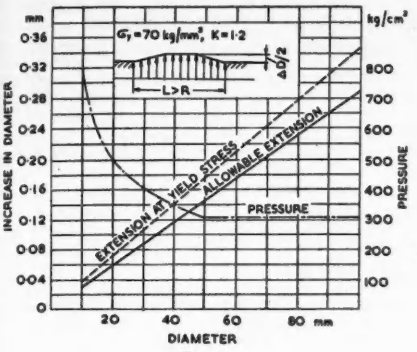



Fig. 9.

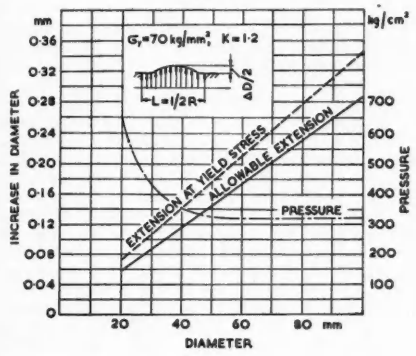



Fig. 10.

obtain a formula of the type $h = A\,D$, where $A = p/(2\,\sigma_{at})$ for long cylinders, and $A = [1 - \varphi\,(x_{L/2})]\,p/(2\,\sigma_{at})$ for short cylinders. Thus, we have expressions similar to those of Table I ; but in large cylinders it is not possible to ensure the practicability of a hydraulic pressure of 300 kg/cm².

To obtain the clamping effect between mandrel and component, let us consider a long cylinder loaded at its centre section by forces uniformly distributed over the circumference. The loading intensity is $q$ in kg/cm². Elastic theory yields the following expression for the maximum radial deflection

$$\Delta R_c = q\,\frac{\beta\,R^2}{2\,E\,h} \qquad .. \qquad .. \qquad (9)$$

where $\beta = 1{\cdot}28/\sqrt{R\,h}$ cm$^{-1}$ for steel.

Let the cylinder under the internal pressure $p$ suffer a radial deflection $\Delta R_{at}$. When inside the component, the extension of the mandrel radius cannot exceed the clearance between mandrel and component. (We consider the component to be rigid). Equating the radial deformation of eq. (9) with the difference between the free and the constrained extension in the radius of the cylinder, we obtain

$$q = \frac{2}{\beta}\,(\Delta R_{at} - \Delta R_{ac})\,\frac{E\,h}{R^2} \qquad .. \qquad (10)$$

where $\Delta R_{ac}$ is the maximum clearance to be expected. The simplifying assumption of concentration of clamping pressure around one section of the cylinder renders a calculated pressure below the actual.

Let the contraction imposed in clamping the component be denoted by $\delta$. Obviously, $\delta = 2(\Delta R_{at} - \Delta R_{ac})$. When $\delta > 0$ the elastic contraction of the mandrel is used for clamping the component. When $\delta = 0$ the mandrel is used only for centering the component.

From these expressions, and the normal laws of friction, assuming a coefficient of friction $f$, we obtain a clamping frictional torque from the following expression

$$T = 5 \times 10^5\,(h/R)^{3/2}\,\delta\,D^2 \quad [\text{kg cm}] \quad .. \quad (11)$$

The starting point for designing the plunger movement is the assumption that the plastic mass, like a perfect liquid, is not compressible. In practice, it is found that in filling the pressure space, casting defects are responsible for the presence of air bubbles, the volume of which reaches 0·1 — 0·3 per cent of the total volume of plastic mass. Thus, when the plunger is moved by a screw of pitch $s$, the total displacement of the plunger measured by $z$ turns is given as follows

$$s\,z = (2\,D\,\Delta D\,L + C\,v_o)/d^2 \qquad .. \qquad (12)$$

where $v_o$ is the volume of the pressure space, and $C = 0{\cdot}001$ to $0{\cdot}003$.

To reduce clamping time, we require a minimum $z$, and hence will endeavour to reduce the volume of the pressure space. Since its length is normally determined by the component to be clamped, we are again advised to reduce to the minimum the annular width of the pressure space. In practice, an excessively small width $H$ (Fig. 7) is difficult to handle in filling the fixture. Experiments have shown that a recommended value for $H$ is

$$H = 2\sqrt[3]{D} \quad [\text{mm}] \quad .. \qquad .. \qquad (13)$$

Tool engineers are primarily interested in the application of plastic-mass-actuated mandrels. We have seen that this must depend on the diameter of the mandrel and on the tolerances of the component to be machined. The maximum allowable expansion of the mandrel must exceed the greatest clearance between mandrel and component which can occur at any time. Generally, the condition of applicability of these mandrels can be expressed by

$$\frac{\sigma_y}{E\,k}\,D = 2\,\Delta R_{ac} + \delta \qquad .. \qquad .. \qquad (14)$$

In the design of fixtures where plastic mass has to transmit pressure through corners and holes, it is important that cross-sections shall be adequate, and that the rheological " pressure losses " through long holes be taken into account. Thus, the transmission of pressure to a large circumference from the centre should be carried out through three or four symmetrically distributed radial holes.

In the manufacture of these mandrel components, it is recommended that the machining of the thin-walled part should be carried out after heat treatment, but the working surface of the mandrel should be finally machined only after filling with plastic mass, assembly with the plunger mechanism, and application of pressure to the assembly.

The clearance in the plunger mechanism must not exceed 0·03 mm to avoid leakage of the plastic mass.

## Preparation of the Plastic Mass

The liquid and powder components are mixed to a uniform mass. Heating takes place in a vessel surrounded by a glycerine bath and must be accompanied by continuous mixing. The mass, originally of dark grey colour, is first transformed from a liquid state into a thick yellow-brown syrup and subsequently becomes liquid again, taking on a deep brown colour. Good mixing is particularly important during the second transformation, where the danger of burning is greatest. Curing is finished when the mass assumes a light brown colour, and a consistency of thin syrup. The vapour which is discharged during curing is dangerous to health, and the process must be carried out in a special ventilated chamber.

The finished plastic mass is poured out into metallic

forms, and cooled to room temperature, when its physical properties resemble those of rubber latex. It must be preserved in a cool dry atmosphere.

The filling of a fixture with plastic mass is carried out after reheating of the plastic mass to 130-150° C in a glycerine bath, with constant mixing. Just before pouring, the temperature is increased to 150-160° C. Contraction of the plastic mass must be taken into account and some form of riser provided. The plastic mass can also be liquefied for emptying the fixture. A temperature of 130-150° C is required.

The composition of the plastic mass is as follows :—

| | | |
|---|---|---|
| Emulsified polyvinyl chloride (PVC) | 100 | parts |
| Dibutyl-phthalate .. .. .. | 290 | „ |
| "Vacuum" oil .. .. .. | 100 | „ |
| Calcium stearate .. .. .. | 4 | „ |

The specific gravity of the plastic mass is 1·018.

SWEDE

# Absolute Hardness Scale

By J. Murkes. (From *Teknisk Tidskrift*, Vol. 82, No. 2, January 15, 1952, pp. 37-40, 3 illustrations.)

*The increasing production of hard alloys and grinding materials has considerably stimulated interest in the correctness and accuracy of hardness determinations. The solutions of many engineering problems depend on the availability of adequate methods for determining hardness.*

## MOHS' HARDNESS SCALE.

For over a century, the hardness of minerals has been assessed by means of Mohs' hardness scale based on the hardnesses of ten different standard materials. The scale, however, is hardly sufficiently comprehensive for all the metals now available. It is not uniform over its entire range. Furthermore, as the hardness of standard materials of the same kind obtained from different localities is not constant, there is no unequivocal relationship between a number in Mohs' scale and a true hardness value.

The major deficiency in Mohs' scale is that it does not fully provide the possibility of differentiating between the degrees of hardness of very hard materials situated in the highest hardness range, i.e., between 9 and 10. This interval is far too great in relation to the lower intervals. Moreover, Mohs' scale does not give adequate possibility of determining the position of a material in this interval.

It is therefore essential at present to find a new and more complete method for assessing hardness. There are two main possibilities. Either Mohs' scale is entirely rejected and regarded as obsolete and a new scale is introduced, or the principal features of Mohs' scale are retained and complemented with suitable modifications.

Before going into this problem, it is necessary to have a clear idea of the methods of investigation which may be applied in order to obtain fully reliable and reproducible results. There are many known methods of hardness determination and it will be useful, therefore, to consider these critically in order to select the most appropriate features. To do this, it is first necessary to find the conditions which must be satisfied by the method considered.

## REQUIREMENTS OF A HARDNESS SCALE.

The main requirements can be listed as follows : (1) The test method must be as simple as possible ; (2) the apparatus must allow measurements to be made on the widest possible range of materials ; from the softest to the hardest, including diamonds ; (3) the hardness number should not be affected by conditions external to the test ; (4) the accuracy of measurement of the impression should be as high as possible ; (5) in the evaluation of the hardness scale, equal importance should be assigned to both the low and the high hardness values, so as to obtain uniform subdivisions.

However, there is a further important point which must be thoroughly considered before being able to choose an adequate test method. This point is that very often the impressions or scratches obtained in hardness investigations on different materials are not comparable among themselves. Even with materials of the same kind (particularly in the case of hard materials), the impressions or scratches may differ according to whether they are formed as the result of plastic deformation or by brittle cracking. The corresponding hardness numbers thus obtained will not be fully comparable with one another, since they are not derived from measurements based on the same property of the material.

For instance, if talc and glass are investigated by measuring the impression produced by an indenter under a load of some hundred grammes, the ratio of the depths of impression or other dimensions is not representative of the ratio of the true hardnesses. In the one case the impression is made by plastic deformation and in the other by brittle cracking of the material. For correct hardness determination, the process must, therefore, give the possibility of obtaining the same type of impression. As the conception of hardness is that of a resistance to plastic deformation, the procedure to be used must produce an impression through plastic deformation and not by brittle cracking, regardless of the degree of hardness of the material.

It has been pointed out by A. V. Shubnikov that various hard bodies behave either as a brittle or as a plastic material according to the manner in which they are acted upon. Williams found that for such materials, with a given type of diamond point, there exists a critical load. Higher than critical loads produce a brittle cracking and lower loads a plastic deformation of the material. These findings show that, by suitable choice of the loads, a plastic impression can be obtained on any material, whatever its hardness may be. Using sufficiently low loads, plastic impressions can be obtained on such materials as quartz, glass, enamel, etc.

On the basis of the above considerations, it is now possible to examine the best known methods and to choose the most suitable procedure, either in order to evolve a new scale or to complete and improve the old hardness scale.

The Brinell test is not adequate for our purpose, primarily because it cannot be applied to very hard materials, although its value is fully established for many cases occurring in practice. Rockwell's method has the disadvantage of a non-uniform scale, which results in a great decrease in sensitivity for very high hardnesses.

Vickers' method enables determinations to be made on very hard materials, using a diamond pyramid, and is based on a uniform scale. However, it has the important drawback that the Vickers apparatus is designed for loads between 1 and 120 kg, the lower limit depending on the accuracy with which the load can be determined, taking account of the frictional losses in the apparatus. For very hard and brittle materials, however, a load of 1 kg is far too high, since this already results in brittle cracking of the material surface. Thus, the Vickers test can be applied only to investigate materials which show a fairly high degree of plasticity at loads above 1 kg, but gives little possibility of investigating very hard and brittle materials.

Various methods based on other principles have been suggested by various investigators, for instance, Bierbaum's scratch test, Rebinder's grinding test and the Hertz-Auerbach method. This latter method is extremely complicated and not suitable for routine investigations. Bierbaum's test requires that the test surface to be investigated should be scratched with a diamond point shaped as the corner of a cube, under an applied load of 3 grammes. This test is mainly intended for hardness determinations of alloys and can be applied to the hardest materials excepting diamond.

The scratch is obtained either by plastic deformation, wear or cracking. The low load and the shape of the point favour plastic deformation, but there is still some uncertainty regarding the conditions under which a similar scratch can be obtained with different materials. The hardness values obtained by the scratch test depend to a considerable extent on the direction of the scratch and the cut of the material relative to its crystal axis. Similar effects can be expected when using grinding methods, but the impression is much weaker than with the indentation tests. The hardness number obtained by grinding methods is more likely to be affected by external conditions and it is essential that the properties of the grinding material should remain constant.

In regard to the three last-mentioned methods, the remark by V. D. Kuznetov can be repeated; these methods, in contrast with the indentation methods, " determine directly or indirectly the brittleness resistance of hard bodies and the surface energy associated with this property.' It is to be expected that the hardness values obtained by these methods will not differ greatly among themselves. They do, however, differ from the results obtained by indentation tests, in which the hardness numbers are related to the resistance of the material to plastic deformation.

Thus, all the methods mentioned have considerable disadvantages. In principle, however, the Vickers test is the most suitable and an apparatus of this type should be constructed for use with lower applied loads. M. M. Chrustiov made his hardness determinations with an apparatus of this kind designed for loads between 2 and 200 grammes. The hardness is determined from the impression of a diamond pyramid with a square base and an apex angle of 136 deg. between opposite faces. The hardness number, in kg/mm², is then calculated from the ratio of the applied load to the lateral surface of the impression:

$$H_D = [2P \sin(\alpha/2)]/d^2 \quad .. \quad .. \quad (1)$$

where $P$ is the load, $d$ the diagonal of the impression, and $\alpha = 136$ deg. in the present case.

This procedure is free from all the disadvantages previously discussed and makes it possible to produce impressions with plastic deformation by means of sufficiently low loads, resulting in a uniform hardness scale. The length of the diagonal of the impression can be measured with a sufficiently high accuracy and the hardness number corresponding to the resistance of the material to plastic deformation will be a constant value for any applied load through the load range used. Furthermore, the method is simple and suitable for the hardness investigation of any type of material including diamond.

In the United States, experiments have been made with a diamond pyramid on a rhomboid base (Knoop's pyramid) having apex angles of 130 deg. and 172·5 deg. The impression produced has the shape of a rhombus and the hardness number is determined as the ratio of the load to the projected area of the impression. However, particularly in regard to microhardness determinations, this method is not quite as suitable as the indentation method with a square-base pyramid point, since under the same load the latter gives a smaller diagonal length and permits greater accuracy of measurement to be obtained.

It would be of interest to compare the hardness determinations obtained by the various methods mentioned above on a single set of specimen materials of varying hardness. An investigation of this kind has not been carried out but results are available of hardness determinations obtained by various investigators for minerals used as a basis for Mohs' scale. These data were collected by Chrustiov from various publications.

Fig. 1 shows, on a logarithmic basis, the hardness values used in Mohs' scale as determined by various investigators. The results are based on the figures of Table I, which have, however, been multiplied by various constants in order to obtain the same value of 2600

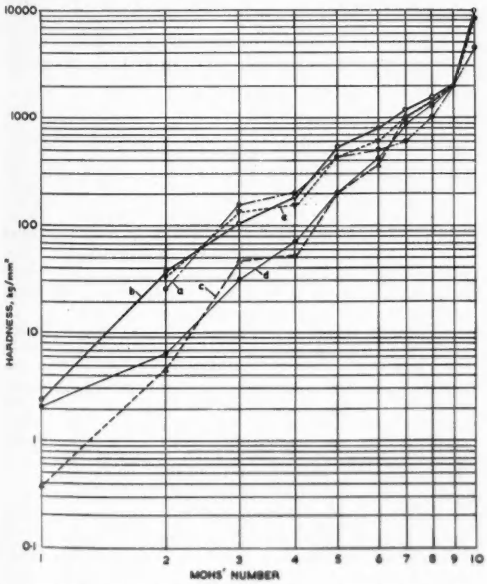



Fig. 1. **Relative hardness values for minerals in Mohs' scale determined by the following methods:** $a$ = Hertz-Auerbach, $b$ = Rebinder, $c$ = Bierbaum, $d$ = Chrustiov, and $e$ = Knoop.

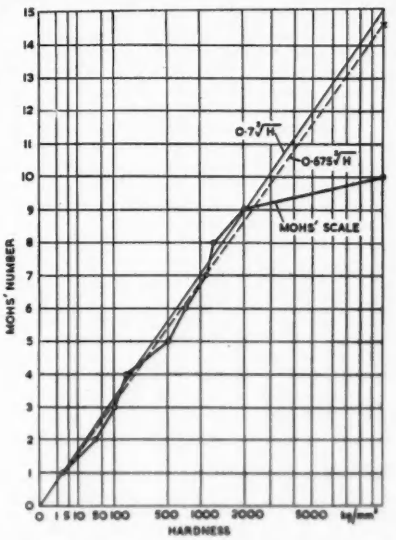



Fig. 2. **Comparison of hardness curves in Mohs' scale and the new scale.**

kg/mm² for the hardness of corundum in all cases. The multiplying factors used are 2·145 for Rebinder's figures, 1·79 for Auerbach's data, 0·39 for those of Hodge and May, and 1·055 for the figures of Peter and Knoop.

TABLE I. HARDNESS NUMBERS OF MINERALS USED IN MOHS' SCALE ACCORDING TO DIFFERENT METHODS.

| Mohs' number | Mineral | Hertz-Auerbach's method $H_A$ kg/mm² | Rebinder's grinding method $H_P$ kg/mm² | Bierbaum's scratch method $k$ kg/mm² | Chrustiov's method $H_D$ kg/mm² | Knoop's pyramid indentation $I$ kg/mm² |
|---|---|---|---|---|---|---|
| 1 | Talc | ... | 1 | 1 | 2·4 | ... |
| 2 | Gypsum | 14 | 3 | 11 | 36 | 32 |
| 3 | Calcite | 92 | 15 | 129 | 109 | 135 |
| 4 | Fluorspar | 110 | 33 | 143 | 189 | 163 |
| 5 | Apatite | 237 | 74 | 517 | 536 | 425 |
| 6 | Feldspar | 253 | 117 | 975 | 795 | 560 |
| 7 | Quartz | 308 | 365 | 2,700 | 1,120 | 750 |
| 8 | Topaz | 525 | 626 | 3,420 | 1,427 | 1,250 |
| 9 | Corundum | 1,150 | 960 | 5,300 | 2,060 | 1,950 |
| 10 | Diamond | (2,500) | ... | ... | 10,060 | 8,250 |

## HARDNESS IN ABSOLUTE VALUES AND BY MOHS' SCALE.

Having decided on the test method and the appropriate type of hardness measuring apparatus, M. M. Chrustiov made a series of determinations in order to find the quantitative relationship between Mohs' number and the true hardness of standard materials used in Mohs' scale.

Special attention was given to the determination of the hardness of diamond. This was obtained by means of an impression of a diamond pyramid with a square base and an apex angle of 136 deg. in conjunction with another diamond pyramid having an equilateral triangular base, with similar dimensions for the side surfaces and heights. The impressions were obtained using loads of 50, 100, 200 and 500 grammes. They showed that there was absolutely no impression on the triangular pyramid at loads below 200 grammes and the square pyramid for loads below 100 grammes, whereas the impression was clearly visible and free of cracks at these same loads in the two corresponding cases.

The hardness values obtained varied with load and pyramid shape, higher hardness numbers being obtained with the square pyramid and with lower loads. The shape effect can be explained by pointing out that the linear dimensions of the square impression are apt to decrease more considerably than those of a triangular impression as a result of elastic hysteresis effects. Moreover, the hardness numbers obtained with low loads give a measure of the surface hardness of diamond, which is increased by grinding. Accordingly, it is considered that the hardness number obtained by the impression of a triangular pyramid under a load of 200 grammes is closest to the true value. According to eq. (1), this value is equal to approximately 10,000 kg/mm².

Fig. 1 shows that the absolute hardness values of all standard materials used in Mohs' scale except the last one (diamond) are situated on an approximately straight line when plotted against Mohs' scale on a log-log basis. The slope of the line is 1/3. Thus, it is possible to replot Mohs' numbers as ordinates against the cube roots of the absolute hardness values used as abscissae, and this gives the broken line of the diagram in Fig. 2. For Mohs' numbers between 0 and 9, this line can be very closely approximated by the relation

$$M = 0{\cdot}675 \sqrt[3]{H} \quad .. \quad .. \quad (2)$$

where $M$ = Mohs' number and $H$ = hardness value in kg/mm² obtained by indentation using a square-base diamond pyramid with an apex angle of 136 deg. If this line is extended to the $H$-value corresponding to diamond hardness, this gives a new Mohs' number for diamond at 14·57.

It is thus evident that the minerals in Mohs' scale are arranged in a remarkably systematic manner and that there is a simple and well-determined positional relationship between corresponding Mohs' numbers and the absolute hardness values in kg/mm². This is an important and valuable result, which could hardly have been assumed *a priori*. Chrustiov proposes that the coefficient 0·675 should be rounded off to 0·7, which simplifies the equation. The new scale deviates very little from Mohs' scale for Mohs' number 9 and offers increased possibility for classifying hard materials.

## THE NEW HARDNESS SCALE.

The new hardness scale is thus based on the following relation :

$$H_0 = 0{\cdot}7 \sqrt[3]{H} \quad .. \quad .. \quad (3)$$

where $H_0$ = new hardness number, and $H$ = hardness in kg/mm² obtained by means of the above-mentioned indentation method.

The new scale completes Mohs' scale in the region of high hardness numbers and its values, calculated by means of eq. (3), differ very little from Mohs' numbers in the interval 1-9 (see Table II).

TABLE II. OLD AND NEW HARDNESS NUMBERS FOR MINERALS IN MOHS' SCALE.

| Mineral | Mohs' number | New hardness number | Mineral | Mohs' number | New hardness number |
|---|---|---|---|---|---|
| Talc | 1 | 0·9 | Feldspar | 6 | 6·5 |
| Gypsum | 2 | 2·3 | Quartz | 7 | 7·3 |
| Calcite | 3 | 3·3 | Topaz | 8 | 7·9 |
| Fluorspar | 4 | 4 | Corundum | 9 | 8·9 |
| Apatite | 5 | 5·7 | Diamond | 10 | 15·1 |

TABLE III. NEW HARDNESS NUMBERS FOR SOME HARD MATERIALS.

| Material | Load grammes | Micro-hardness kg/mm² | Hardness number |
|---|---|---|---|
| Tungsten carbide ... ... | 100 | 1,430 | 7·8 |
| Corundum ... ... ... | 50 | 2,060 | 8·9 |
| Alloys of tungsten and titanium carbide ... ... | 100 | 2,145 | 9·0 |
| Titanium carbide ... ... | 100 | 2,900 | 10·0 |
| Silicon carbide ... ... | 50 | 3,000 | 10·1 |
| Diamond ... ... ... | 200 | 10,060 | 15·1 |

The new hardness numbers are no longer approximate figures, related to certain standard materials, but are a clear and accurate measure of the hardness of the material in kg/mm². The hardness is indicated in whole numbers followed by a decimal. The whole number characterises the hardness class and the decimal indicates the "position" of the material in this class. This makes it possible, for instance, to assess and differentiate between the hardnesses of similar materials of different origin, which was impossible with the old scale.

The new scale has the further advantage over Mohs' scale that the interval 9-10 (corundum-diamond) is subdivided into six hardness classes, since the new hardness number of diamond is 15·1. A more accurate classification of all hard materials, which previously were situated at the end of one hardness class, is now possible (see Table III). The new hardness scale is applicable to all materials (minerals, metals, ceramics, etc.), and fulfils all the requisites of a fundamental scale for the assessment of hardness for both soft and hard materials.

It is quite possible that, in some future time, some further, more accurate hardness value for diamond may be obtained, but this will not cause an alteration of the entire scale. Only diamond will have to be assigned a new hardness number.*

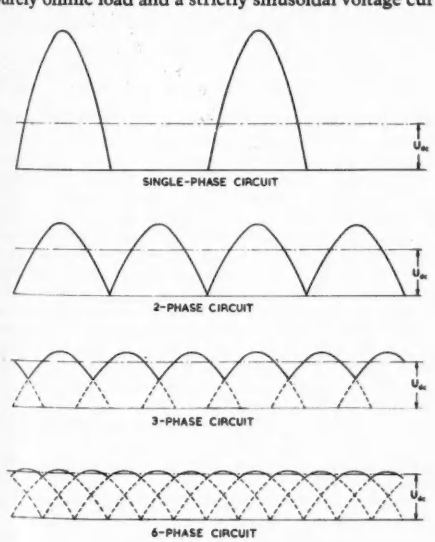
* The original article includes a bibliography with 17 references.

# The Influence of the Wave Forms of Rectified Alternating Current on the Growth of Galvanic Deposits

By M. E. Beckmann and F. Maass-Graefe. (From *Metalloberfläche*, Vol. 5, No. 11, November, 1951, pp. A161-A169, 42 illustrations.)

*Investigation showed that when zinc, copper, nickel and chromium are deposited from galvanic baths, the grain structure of the coating is, in most cases, not influenced by the wave form of the rectified current. Exceptions were found in the case of hard chromium baths and of alkaline zinc cyanide baths with single-phase rectification.*

The object of the tests described in this paper was to ascertain whether there is any difference in crystal growth as a result of the particular type of current supply. The micro-sections of the deposits were therefore carefully studied. The tests covered the following baths : alkaline and acid zinc baths ; alkaline and acid copper baths ; the acid nickel bath ; and the chromium bath. The test equipment consisted of a current supply unit comprising dry rectifier units in single-, two-, three- and six-phase circuits together with main and tapped transformers in series, and, for purposes of comparison, a battery. The rectifier units and the series transformers for coupling to a polyphase current of 380 V at 50 cps were in each case designed for a maximum direct current output of 20 A at 20 V. The bath voltage and current intensity were adjusted by regulating the resistance on the primary side of the rectifier-transformer in the single- and two-phase units, by choosing suitable transformer tappings in the three- and six-phase units, and by the simple regulation of resistance in the battery unit. The voltages and currents appearing on the direct-current side of the rectifier unit are illustrated in Figs. 1-4, where the course of the d.c. voltages for the currents in question is considered in the case of no-load or of simple resistance load. In the single-phase circuit, there is a voltage curve as in Fig. 1 where, when the rectifier is supplied with a 50-cycle alternating current during 1/100 sec, there is a voltage or current output followed by a non-voltage or non-current period of equal duration. The curves for the two- three- and six-phase circuits are shown in Figs. 2, 3 and 4, from which it is seen that in the latter two cases the voltage does not vanish altogether. The course of all the voltage or current impulses follows or partly follows a sinusoidal line. With a purely ohmic load and a strictly sinusoidal voltage curve,




**Figs. 1-4. Voltage curves.**

the frequency and the effective value of the superimposed alternating voltage component, expressed as a percentage of the arithmetical mean of the direct voltage delivered, is as follows :

Single-phase circuit, frequency 50—superimposed alternating voltage 121 per cent

2-phase circuit, frequency 100—superimposed alternating voltage 48 per cent

3-phase circuit, frequency 150—superimposed alternating voltage 18 per cent

6-phase circuit, frequency 300—superimposed alternating voltage 4 per cent.

The voltage and current curves, when galvanic baths are fed from rectifying units, are further influenced by the polarisation voltage generated by such baths. Various factors affect the magnitude of this influence. An analysis of the current and voltage forms was therefore required in order to interpret the electrolytic processes. In the analysis of the current curve, the arithmetical mean of the instantaneous values represents the equivalent direct current value $I_{dc}$ and the square of the mean value represents the effective value $I_w$ of the wave current. The component of the superimposed alternating current is then given by the relation

$$I_w^2 = I_{dc}^2 + I_{ac}^2$$

where $I_{ac}$ signifies the effective value of the superimposed alternating current. The analysis of the voltage curve is carried out similarly and the relation obtained is

$$U_w^2 = U_{dc}^2 + U_{ac}^2$$

In both cases, the measurement of the arithmetical mean value is effected by moving coil instruments with a sufficiently damped measuring system. As a control, the effective value of the superimposed alternating current and voltage component was determined by means of a moving coil instrument with series rectifier and a capacitor of suitable magnitude intended to block the direct-current part. The measured values were confirmed by observing the current and voltage curves with an oscillograph. Fig. 5 shows the wiring diagram of the circuits used for the measurements ; in each case the starting point was the arithmetical mean $I_{dc}$ of the current fed to the baths. Rectangular glass troughs with a 3-litre capacity were used as baths, with the exception of the chromium bath. The cathode was arranged in the middle between two anodes attached to the sides of the baths. The distance between the electrodes was 75 mm (3 in.) on average. Electrolysis was usually carried out with a single- or 6-phase rectifier unit without employing any special smoothing circuit, and for comparison also with an ideal direct current from a battery. In special cases, the tests were repeated with 2- or 3-phase rectification. The tests themselves were carried out as follows :—

*Zinc.* For the alkaline zinc cyanide baths, use was made of a mat zinc bath and a bright zinc bath. The anodes consisted of fine zinc with a zinc content of 99·99 per cent. The deposits were made on etched rolled zinc plates. For judging the surfaces, coats 15$\mu$ in thickness were also deposited on mechanically polished deep-drawing sheet. The electrolysis was done at a temperature of 20° C. The grain structure of the deposits from the bright zinc bath was practically

identical for the three different kinds of current supply. A grain structure very similar to these was obtained in the deposits from the mat zinc bath with battery and 6-phase current. The layers from the single-phase arrangement differed in that the individual crystals were branched and their direction of growth varied. Two acid zinc baths also were employed. The deposits from the mat zinc bath were similar in all three cases and consisted of coarse crystals which penetrated the entire layer. In the presence of furfurol, coarse crystals were formed which did not display any special peculiarities. These tests showed that only in the alkaline zinc cyanide bath with single-phase rectification was there observed a slight influence of the wave form on crystal growth.

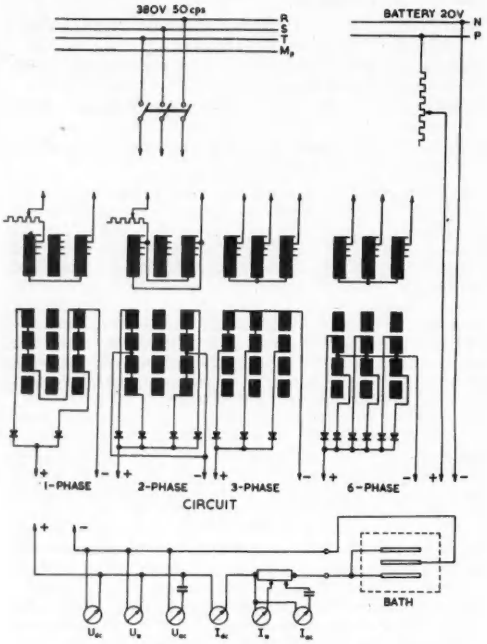



Fig. 5. **Wiring diagram.**

*Copper.* The alkaline copper cyanide bath tests showed that, as expected, the cathode current yield at low current densities is greater than at high densities. The metallographic examination of the surface and grain structure showed that the wave form of the rectified alternating current did not exert any influence on crystal growth. The results of the acid copper baths tests again showed that there is no difference in the grain structure of the coatings either in the very fine grain deposits from the bath with organic additions or in the coarse grain deposits from the bath without additions. The wave form of the rectified current exerts practically no influence on the cathode current yield in the acid copper bath.

*Acid nickel bath.* The pH value of the bath was adjusted with sulphuric acid to 5·6. The anodes consisted of electrolytic nickel, the cathodes being of recrystallised rolled copper. The metallographic investigation did not show any difference in the grain structure of the deposits when a battery or single- or 6-phase rectifier current was used. A study was also made to determine whether the type of current supply had any influence on the porosity of the plating. The number of pores was ascertained by the ferroxyl test. On average, the layers with 6-phase rectification had the least porosity. It was also found that the current yield is higher in the case of single-phase rectification than in that of 6-phase rectification.

*The hard chromium bath.* The container was a lead-coated iron bath of 2 litres capacity. The anodes were of hard lead, and the distance between the electrodes was 55 mm. With single-phase rectification, the chromium coats were a dull grey, unlike those produced by the other forms of current, which had the customary bright appearance. There is still no satisfactory explanation of the reason for this difference. The microscopic study disclosed no essential difference between battery current and rectified single-, two-, three-, or six-phase current. The examination with polarised light of the chromium layers deposited with single-phase rectification showed that an optically anisotropic crystal lattice must be present here. Hard chromium layers usually crystallise in the cubic system, which is optically isotropic. It is suggested that in the single-phase rectification, the hexagonal modification of chromium is present which has already been mentioned in literature. It is unstable and the conditions for its production are not known with certainty. Hence, of the baths examined, the hard chromium bath is the only one displaying a fundamental difference in the grain structure of the deposits, due to the large wave form of the rectified alternating current arising in the one-way rectification of the single-phase alternating current of 50 cps. The cathode current yield was particularly small with the 2-phase rectification, being 15 per cent, while with the other types of current it was between 18 and 20 per cent. No satisfactory explanation for this has been found.

## Reversed Cycles for Simultaneous Heating and Cooling

By V. MARTYNOVSKY. (From *Kholodilnaya Tekhnika, Russia*, No. 3, 1951, pp. 51-53, 3 illustrations.).

THE ordinary ammonia vapour plant working at a level of temperatures suitable for refrigeration also delivers some heat at a temperature above the ambient. However, even under extreme conditions, this amount of heat does not exceed one-fifth of the total heat exchanged in the condenser. In principle, it would be possible, by raising the temperature of condensation in the ammonia cycle, to obtain simultaneous heating and cooling; but the practical realisation of such a cycle is associated with the very high pressure to which the refrigerating medium must be compressed.

Modern advances in the construction of gas turbines have created the necessary conditions for the improvement of the reversed air cycle, particularly with regeneration in a heat exchanger. The thermodynamic merit of the reversed cycle is measured by the ratio of its coefficient of performance to the coefficient of performance of a Carnot cycle, working between the same temperatures.

The author derives a family of curves, illustrated in Fig. 1, which give the thermodynamic merit of the regenerative open air cycle with an ideal regenerator, in relation to the ratio of temperatures of heat addition and extraction. Each curve corresponds to a given quality of the compressor and turbine, measured by the product of their adiabatic efficiencies. This graph illustrates why the air cycle is inefficient in refrigeration, where the ratio of temperatures is between 0·8 and 0·9, but becomes much more efficient in a heat pump, where this ratio reaches 6. Even the introduction of a temperature drop in the regenerator leaves an acceptable degree of thermodynamic merit.

The use of the air cycle is particularly appropriate where the heating and cooling processes can be advantageously conducted at rising and falling temperatures respectively. The author also investigates the

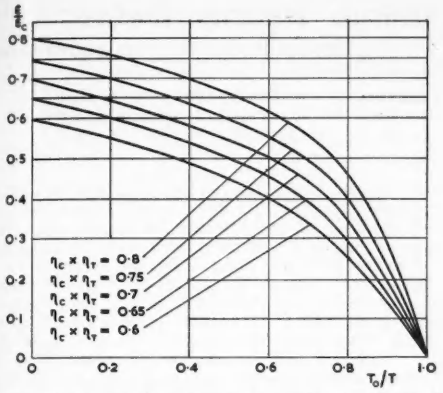



Fig. 1. **Degree of thermodynamic merit of regenerative air cycle with ideal regenerator in relation to the temperature ratio.**

$T_0$ Temperature of cold reservoir.
$T$ Temperature of hot reservoir.
$\epsilon$ Coefficient of performance of actual cycle.
$\epsilon_C$ Coefficient of performance of Carnot cycle.
$\eta_C$ Adiabatic efficiency of compressor.
$\eta_T$ Adiabatic efficiency of expansion turbine.

carbon dioxide cycle with regeneration, but without the use of an expansion turbine, and finds that a satisfactory degree of thermodynamic merit can be achieved in a combined installation for heating and cooling.

The author's conclusions are as follows :

(1) The reversed regenerative air cycle used in a combined installation possesses a much higher degree of thermodynamic merit than the same cycle worked between temperatures common in refrigeration.

(2) The limiting value of the thermodynamic merit of the reversed regenerative gas cycle (with ideal regeneration) can, with modern gas turbine design, reach values of 45-55 per cent at suitable temperature ratios.

(3) The low-pressure regenerative vapour cycle used in a combined installation for heating and refrigeration yields heat of relatively high temperature with an acceptable degree of thermodynamic merit.

## Quality Control of Lead-Bronze Bearings

By E. Uhlir. (From *Maschinenbau und Wärmewirtschaft, Austria*, Vol. 7, No. 1, January, 1952, pp. 4-8, 9 illustrations.)

The main types of copper alloys now used as bearing materials can be classified into four groups, viz. : binary lead bronze, binary lead bronze with up to 2 per cent additions, lead tin bronze, and special lead-bronze with three to five components. The lead content is between 10 and 35 per cent for the binary alloys, 4-22 per cent for ternary lead tin bronzes, and 10-35 per cent approximately for the special lead bronzes.

The binary alloys have low hardness values, 25-50 Brinell at room temperature, decreasing to about 8 Brinell at 250° C. Their hardness, therefore, is not appreciably reduced at normal operating temperatures, but in order to prevent distortion these binary alloys are always provided with a steel backing, generally 8 mm thick, whereas the thickness of the cast material after the finishing operation is 0·4-0·8 mm. Bearings made from the other lead-bronze materials are harder and do not require a steel backing.

The binary lead-bronze bearings have good running properties even under extreme conditions and can withstand loads up to 350 kg/cm² at sliding velocities of about 10 m/sec. Owing to their high specific loading capacity, shorter bearings, with an $L/D$ ratio of about 0·6, can be used, and this corresponds to a considerable reduction in edge pressure. Binary lead-bronzes are used mainly for journal and big end bearings, as well as for thrust bearings in turbines, locomotives, etc. The running surfaces of the shafting should be hardened to about 50 Rockwell-C; annealed shaft materials are suitable only with soft bearings having a hardness below 30 Brinell. These bearings are always pressure-lubricated, the oil serving also for heat dissipation.

As the two alloy components are insoluble in the solid state and solidify at considerably different temperatures, the difficulties of manufacture of these compound cast bearings are considerable. In melts of binary copper lead alloys, the primary copper begins to precipitate at 970° C, and, with further cooling, solidification of the copper continues down to the eutectic point (36 per cent copper). At 954° C, 92·5 per cent of the copper has solidified, and the melt consists mainly of lead. At 326° C, the solidification temperature of lead, all the copper is already solid and forms a matrix in which the lead is embedded. Below this temperature, the binary copper lead alloy consists, therefore, of a copper matrix in which the lead is more or less finely dispersed, according to the rate of cooling. To obtain good sliding properties, the melt should thus be cooled down as rapidly as possible, the aim being to obtain a fine, dense structure with a uniform lead distribution, as well as a good bonding of the alloy to the supporting steel backing.

To overcome manufacturing difficulties, many casting processes were developed, which differ mainly in the type of preheating applied to the supporting shell and the introduction of the melt. If the molten copper lead is cooled too slowly, segregation occurs, and if the rate of cooling is too high, this results in the formation of voids and porosities occurring in the form of clusters.

These defects substantially reduce the running properties of the bearing surfaces, so that it is generally necessary to check the quality of the linings before putting them into service. The inspection consists mainly in a hardness determination, followed by an X-ray examination to detect cracks, cavities or inclusions. The chemical composition and microstructure are investigated only in random tests.

Although the hardness test and the random tests associated with chemical analysis and microstructure investigation do not appreciably slow down production, the radiological investigation is expensive and takes time even with adequate equipment.

In order to be able to detect the defective linings, it was thus necessary to develop a new and simple method of testing which can easily be integrated in the production process. The following procedure can be said to fulfil these requirements.

For the purpose of the investigation, during the machining of the lining the cutting speed is reduced to about 0·5 metre per minute and the chips are removed with the tool set at a cutting angle of 80 deg. As a result, the chips and shavings formed are torn off the surface. A bearing lining machined in this manner will have a rough and unclean surface ; this surface, however, will show all the defects and even enable a non-uniform lead distribution to be clearly recognised from the different appearance of the metal.

Normally, in the finishing operation, carried out at usual cutting speeds using a diamond or hard-metal tool, a smooth surface is obtained, in which, owing to plastic deformation, the defects are no longer recognisable.

Numerous investigations of compound lead-bronze bearings showed that existing defects were never confined to a particular area only but were distributed

(*Concluded on page* 120)

U. S. A.

# Direct Reduction Yields Variable Density Steels

By P. E. CAVANAGH. (From *The Iron Age*, Vol. 169, Nos. 4 and 5, January 24 and 31, 1952, pp. 63-68 and pp. 108-111, 114 respectively, 12 illustrations.)

*Fine, prepared ore or mill scale is reduced with coke and limestone in a continuous kiln, yielding plain carbon or alloyed steel. Bars, slabs, pipe and other shapes have been produced with densities of 1·0 to 7·2 grams per cubic centimetre. At same weight as aluminium, this light steel is weaker but much cheaper.*

THE Ontario Research Foundation has developed a process for producing useful articles of steel directly from iron ore. The simple process involved was discovered by accident. While investigating the possibilities of producing sponge iron commercially, part of the work was devoted to the production of sponge iron suitable for processing into iron powder. To speed up reduction time, sponge iron was produced in bars or wedges. Sponge iron bars intended to be ground into iron powder were reduced at a relatively low temperature. They were friable and easily broken up. However, a few bars accidentally produced were so hard, strong and tough that they could not be ground up.

A laboratory investigation was immediately started to try to produce this material deliberately. This did not seem a very promising project, since direct reduction usually gives a density of 3·0 g per cc or less. It was thought desirable to produce a metal with densities of 4·0, 5·0, 6·0 or higher. All past experience suggested that any attempt to obtain such high densities directly from iron ore would result in cracked and broken pieces.

Experience in producing extruded pellets from various iron ores indicated the way in which this difficulty could be overcome.

The density of the steel is determined by several factors. Different iron oxides and different ore deposits of the same oxide behave differently during heating and reduction. Some ores will swell remarkably during this process, while others shrink as much as 50 per cent in volume. The swelling or shrinking characteristics of the ore can be modified by adjusting the screen size distribution of the ground ore. This gives more or fewer voids in the final product and, therefore, some control of density. Final density of the steel can be increased by carrying on reduction and treatment at higher temperatures and for longer times.

Carbon content of the steel products is determined by three factors. These are: composition of the reducing gas, reduction temperature and period of treatment at temperature after complete reduction has been achieved. Carbon content and density can, therefore, be separately controlled even with the same ore.

Success with the present method depends on a complete knowledge of the behaviour of the iron oxide raw material during reduction. Fig. 1 and Tables I and II show some of the results obtained with a variety of ores (extruded in the form of $\frac{1}{2}$ in. dia. rods) and illustrate the necessity of such preliminary studies. In addition, dilatometer studies of such extruded ore fines can be made at all stages of reduction.

If a given ore undergoes a volume increase of 10 per cent, it is possible to reduce the amount of swelling markedly. This is done by grinding the ore to a lower bulk density. An ore with pronounced shrinking tendencies can be blended with a swelling ore.

For production of parts with densities of 5·0 or higher, the use of a shrinking ore is indicated. The density of the product obtained from a given reduction process can be further increased by adding to the ore small percentages of salt, metallic iron powder and copper. The salt apparently acts as a cleansing agent. It keeps the reduced surface of the iron particles easily accessible to reducing gas and promotes sintering. The metallic iron takes up oxygen from the reducing gas and promotes faster reduction. This leaves more of the cycle time for sintering. The addition of copper appears to be beneficial for the same reasons as in iron powder metallurgy, when carried out above the melting point of copper.

Some unexpectedly high densities are sometimes obtained by blending a swelling ore with a shrinking ore.

For many possible applications of controlled density steel it is obviously necessary to start with an extremely clean and pure iron oxide. The success which has been attained is due entirely to the 3-phase magnetic superconcentrator.

This equipment is in essence the stator of a 3-phase

TABLE I. EFFECTS OF ORE CHARACTERISTICS, TIME, TEMPERATURE AND REDUCER ON DENSITY

| Ore | Iron, % | Silica, % | Oxygen Loss, % | Extruded density | Per cent change in density | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Hydrogen reduction | | | | Carbon monoxide reduction | | | |
| | | | | | 1,850° F | | 2,000° F | | 1,850° F | | 2,000° F | |
| | | | | | 1 hr | 3 hr | 1 hr | 3 hr | 1 hr | 3 hr | 1 hr | 3 hr |
| Cornwall magnetite ... | 60·0 | 4·3 | 23 | 3·15 | −24·0 | −23·5 | −22·5 | −23·7 | −42·5 | −31·5 | − 7·6 | −28·8 |
| Beneficiated hematite... | 60·5 | 9·1 | 26 | 2·75 | −20·0 | −16·0 | −27·6 | −20·7 | −31·2 | −27·3 | −22·9 | −31·3 |
| El Pao ... ... ... | 68·5 | 1·2 | 26 | 3·25 | −24·1 | −19·5 | −33·5 | −20·2 | −53·0 | −38·0 | −45·0 | −38·0 |
| Pure magnetite ... | 72·5 | ... | 26·5 | 2·60 | + 4·0 | +51·4 | + 7·2 | +12·8 | − 5·4 | + 7·2 | +52·0 | +28·0 |
| Steep Rock hematite ... | 54·4 | 4·0 | 28 | 2·70 | −14·4 | −10·0 | −11·3 | −16·0 | −20·0 | − 6·3 | 0 | −11·0 |
| Oliver hematite ... | 54·5 | 12·5 | 23·5 | 2·40 | −18·3 | −21·3 | −13·5 | −18·0 | −20·2 | −16·6 | +31·0 | −11·5 |
| Pure hematite ... | 70·0 | ... | 29 | 2·70 | +36·0 | +39·1 | +48·5 | +34·7 | +19·6 | +38·5 | +31·1 | +32·4 |
| Hematite 20%, magnetite 80% ... ... | 71·3 | ... | 27 | 2·60 | ... | +19·0 | +30·3 | +33·0 | − 5·7 | + 6·0 | +34·2 | +26·2 |

TABLE II. EFFECTS OF SIZE DISTRIBUTION, PARTICLE SHAPE, AND GRINDING METHOD ON DENSITY

| Method of grinding | Screen size distribution, per cent | | | | | | | | Bulk density, g per cc | Surface area | Extruded density, g per cc | Final density, g per cc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | +28 | +48 | +60 | +80 | +100 | +150 | +200 | −200 | | | | |
| Disc grinder ... ... | ... | ... | 0·3 | 14·9 | 14·5 | 13·8 | 19·0 | 37·3 | 2·83 | 29·8 | 3·37 | 6·87 |
| Pan mill ... ... ... | ... | ... | 2·5 | 14·6 | 15·4 | 12·6 | 17·1 | 37·7 | 2·68 | 29·5 | 3·61 | 6·30 |
| Rolls ... ... ... | ... | ... | 0·3 | 13·8 | 17·9 | 19·8 | 14·9 | 33·4 | 2·68 | 27·7 | 3·30 | 6·06 |
| Ball mill ... ... ... | ... | ... | ... | 11·0 | 11·7 | 22·4 | 19·7 | 45·0 | 2·75 | 33·3 | 3·38 | 5·06 |
| Jaw crusher ... ... | 6·5 | 57·0 | 22·7 | 13·6 | ... | ... | ... | ... | 2·78 | 6·8 | 3·21 | 4·21 |
| Screened from jaw crusher | ... | 100·0 | ... | ... | ... | ... | ... | ... | 2·64 | 5·7 | 3·21 | 3·67 |

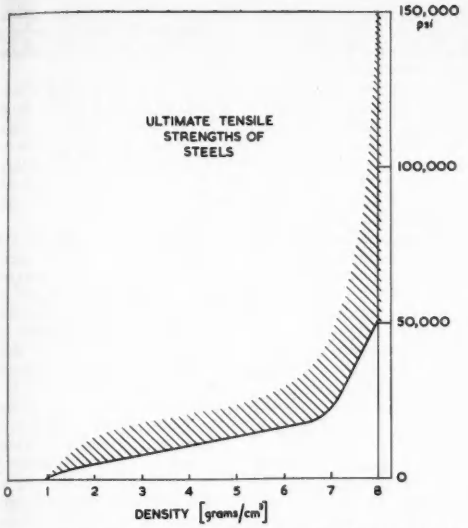



Fig. 1. **Solid line represents minimum tensile strength of satisfactory "low-carbon" bars "as produced." Shaded area indicates that tensile strength at any density can be improved by increasing carbon content, heat treating or other means.**

induction motor spread out flat. A travelling magnetic field is established on the under-surface of the magnet. Fine particles of magnetic iron oxide fed underneath this magnet are rapidly transported through the air to the other end of the magnet. In addition to the forward motion of the particles a very rapid spin is imparted to them for the same reasons that an induction motor shaft turns in a similar field.

As long as a magnetic ore is ground sufficiently to free all the particles of gangue, these will fall into the concentrator's tailings bin. Magnetic particles travel under the magnet to the far end, where they are dropped out of the magnetic field.

Mill scale is an ideal raw material after cleaning on the superconcentrator.

When hematites are available at a sufficiently low price, it may be more profitable to carry out a magnetizing roast and then to clean the magnetic oxide with the superconcentrator.

The choice between these three materials will be determined by their price, special treatment costs for this process, and the suitability of the particular ore in producing the desired density and carbon content in the finished article.

In many instances, controlled density steel articles are produced in usable form. In such a case the allowable level of impurities is determined by the service required of the article. The effect of these impurities in normal steel-working processes is not a factor. For example, if a certain part is not to be hot worked, hot-shortness due to a high sulphur content may be of no importance. The allowable sulphur content would then be determined by the mechanical or other properties required in the finished article.

This means that many ores which do not make desirable blast furnace feed, such as pyrite cinders and titaniferous magnetites, are perfectly satisfactory for this process.

When reduction is carried out by packing in solid carbon, the reducing agent is carbon monoxide generated from the hot carbonaceous reducer. Carburizing compound, coke dust, coal, charcoal, or even sawdust may be utilized as the solid reducing agent. About 10 per cent by weight of limestone must be added to most solid reducing agents. This material takes up sulphur and prevents it from being absorbed by the steel.

The prepared iron ore is poured into a suitable mould and the mould is then vibrated. The main purpose of the mould is to form the loose fine ore into the desired shape and to hold it in that shape until the coke has been packed around it. After the mould is supported by the coke it does not matter whether the mould is burned away, since the fine, close-packed coke will now support the ore in the desired shape. It is possible, therefore, to use moulds of paper. Such moulds char during reduction but produce usable shapes.

Moulds must also be porous so that the reducing gas can pass through them to reach the iron oxide. Porous sand moulds, graphite and shell moulds of resin-bonded sand are all satisfactory.

The tunnel kiln process as carried on at the Foundation's Oakville pilot plant is quite simple. If bars are being produced, the prepared ore is poured into paper tubes. The closed tubes are then placed in a metal container or "sagger" and the fine reducing mix of coke and limestone is added. A 1-in. layer of reducing mix is placed over the top of the tubes and the sagger is sealed to exclude as much air as possible.

Saggers may be of clay or of alloy metal. They must be gas-tight and able to withstand the reduction temperature. The saggers are placed on kiln cars and pushed into the charging end of the kiln.

The main characteristics of the new engineering material provided by this direct reduction process are low cost and light weight. The mechanical properties vary in proportion to density, but they also depend somewhat upon the shape of the finished article. During reduction and sintering operations different thicknesses will reduce and sinter at different rates. This fact must be kept in mind when evaluating the strength of light steel. It is desirable, where possible, to measure the mechanical properties of the actual shape rather than those of specially prepared test bars.

The mechanical properties of the very low density material are comparable to those of wood or plastics. At the same densities, the ductility is considerably below that of magnesium or aluminium. The price per unit volume is also considerably lower.

Light steel will rust more rapidly than normal steel. However, the relatively rough surface of light steel as it comes from the furnace is an ideal surface for painting and particularly for enamelling. It is easy to machine, and nails and screws can be driven into it by hand.

TABLE III. LIGHT STEEL ANALYSES*

| Ore | Additions | C | S | Mn | Si | Cr | Ni | Co | Va |
|---|---|---|---|---|---|---|---|---|---|
| Mill scale ... | | ... | 0·010 | 0·39 | 0·38 | ... | ... | ... | ... |
| Gallivare magnetite | | ... | 0·005 | 0·06 | 0·02 | ... | ... | ... | ... |
| Mag Iron Co. magnetite | | ... | 0·011 | 0·06 | 0·23 | ... | ... | ... | ... |
| Grangesberg magnetite | | ... | 0·014 | 0·05 | 0·06 | ... | ... | ... | ... |
| Mill scale ... | Nickel and chromium powder | 0·14 | 0·007 | 0·17 | 0·34 | 2·00 | 24·14 | ... | ... |
| Mill scale ... | Chromium powder | 1·26 | 0·015 | 0·36 | 0·31 | 0·99 | ... | ... | ... |
| Mill scale ... | Cobalt powder | 1·07 | 0·002 | 0·39 | 0·34 | ... | ... | 26·72 | ... |
| Mill scale ... | Vanadium powder | 0·75 | 0·012 | 0·07 | 0·87 | ... | ... | ... | 0·03 |
| Mill scale ... | Nickel and chromium powder | 2·42 | ... | ... | ... | 8·1 | 5·90 | ... | ... |

*Ores ground to 60 mesh and reduced by packing in paper tubes in a sagger in coke-limestone reducer and holding 36 hr at 2,000° F.

As with ordinary steel, alloying, raising the carbon content, and heat treatment can all be used to increase properties at a given density.

With alloying elements such as cobalt and nickel, the metal may be added in oxide form. The oxide will be reduced and the resulting metal will alloy with the light steel during the process. Table III lists some of the alloys already produced.

The impact strength of low-density steel is limited. Therefore it is sometimes desirable to reinforce the material by placing rods of steel or other metals in the ore when it is moulded into shape.

A " sandwich " construction has been produced in which two thin sheets of stainless steel are placed ½ in. apart and the space filled with fine iron ore. One sheet is pierced with ¼-in. holes placed about 1 in. apart to allow access of reducing gases. The light steel filler has a density between 1·0 and 1·5 g per cc. The bond to the stainless sheets is satisfactory.

One of the annoying characteristics of any direct reduction process is that reduction takes place from the surface inward. It is quite common to find experimental sponge iron or controlled density steel parts which have not been reduced completely through. Sufficient time has not been allowed to complete reduction through the piece. This can be used to advantage in making hollow shapes. For example, a solid bar was reduced at such a fast cycle that only the outer skin was reduced to controlled density steel. Afterwards, the unreduced iron ore in the centre was spilled out, leaving a hollow pipe. Under such circumstances the carbon content is always low. If a higher carbon content is desired, it is possible to re-pass the part through the furnace a second time after removing the unreduced centre. The density will then remain about the same but the carbon content will rise. Any unreduced material adhering to the pipe's inside surfaces is easily removed—hand reaming has been successfully employed.

Such pipes can be enamelled inside. Their weight is about one-third that of cast iron pipe. They can carry corrosive liquids and should cost less than cast iron.

Tests made under gas pressure as high as 2,000 psi have indicated that very-low-density steels (under 3·0) will leak to some extent.

The shell-moulding technique is the preferred way of producing light steel parts to close tolerances. The surface finish is as good as a cast iron finish. It can be considerably improved by using fine sand for the mould and finer maximum screen size in the ore. Experiments are being carried out with resin-bonded test moulds, replacing the sand with a reducing agent so that the mould performs a useful function in reduction.

In the production of simple parts such as bars, tubes and angles, the extrusion technique* developed for iron ore can be used. No supporting moulds are then needed. A binder such as starch will give sufficient green strength so that the extruded shape can be handled and packed in the sagger. The cereal type of binder provides some reducing action in the process. Other binders such as low-sulphur tar or thermo-setting resins can also be considered.

It appears possible to get slightly better mechanical properties in controlled density steel parts of the same analysis and density than in corresponding pressed powder parts. This is probably due to the fact that sintering takes place during and immediately following reduction. There is no chance for formation of any oxide films on the iron particles. The competition with iron powder would seem to be successful where only a small amount of machining is necessary to provide the same tolerances achieved directly in pressed powder parts. The tolerances that can be expected from controlled density steel are somewhere between precision casting and ordinary casting. They do not approach the tolerances of pressed metal parts.

In order to replace a powdered metal part, the cost of finish machining on the controlled density part must be less than the savings accomplished by this new process's ability to eliminate some of the production steps and equipment common to powder metallurgy. As an example, where a simple shape of light steel can be produced as a blank for cold coining, there are possibilities of significant savings.

Because the voids in controlled density steel are not interconnected, it is possible to reheat and hot work the material without any unusual provisions to protect the surface against oxidation. Bars and slabs of controlled density steel can be hot worked to the full density of normal steel. The new material cannot be hot worked in the same way as ordinary steel. Any attempt to put it through standard rolling mill passes will simply smash the cellular structure.

The best method of working a round bar is by hot swaging at about 1,900° F. The best method of rolling sheet is either in a closed pass mill or a mill equipped with following edge mills. The hot working of controlled density steel bears many similarities to the hot working of tungsten and molybdenum. There is one very important difference. It is possible to hot work controlled density steel above the welding temperature (about 2,400° F) so that voids will be welded closed during the process.

Some of the voids will contain impurities or have surface conditions unfavourable for welding. At some point in the hot working of the material these unwelded voids will work to the surface. The surface will then appear badly checked. However, the next pass, still above the welding temperature, will produce a good, hot-worked finish.

Some of the unique possibilities of controlled density steel will be apparent when it is realized that alloy additions can be made, for example, only to the surfaces of sheet slabs. Controlled rolling of such slabs may well provide a satisfactory full-density surface while leaving the interior at low density.

The problem of producing normal steel from controlled density steel at a reasonable cost is very largely a matter of furnace design. If an extremely efficient furnace can be designed to handle large tonnages rapidly, it may be possible in future to revise present estimates of the production costs of such steel.

At present, with existing furnaces, this method for hot working controlled density steel to produce normal steel should be particularly applicable to production of some alloy steels, to production in remote locations and to provision of a completely controlled source of small tonnages of steel.

*Cavanagh, P. E., " Pelletizing of Iron-Bearing Fines by Extrusion ", AIME Blast Furnace, Coke Oven and Raw Materials Conference Proceedings, Vol. 9, 1950, p. 54.

## QUALITY CONTROL OF LEAD-BRONZE BEARINGS

(*Concluded from page* 117)

throughout almost the entire thickness of the lining, in all the bearings investigated.

The new method can, therefore, be used during the preliminary or rough machining of the bearing, in order to assess the quality of the lining. A clear indication is obtained of any defects such as voids, porosities and non-metallic or partially oxidised inclusions, as well as of non-uniform lead distribution. This information is then easily completed by hardness tests as well as chemical analyses and microstructure investigations of random specimens.

The results obtained by this method were compared with those of extensive X-ray macrostructure investigations and showed complete agreement in all cases.

# BRITISH INDUSTRIES FAIR, 1952

*The 31st British Industries Fair will be held from May 5 to 16 simultaneously at Olympia and Earls Court, London, and at Castle Bromwich, Birmingham.*

*From advance information already received we describe in the following pages a small number of exhibits. A review of further exhibits will be published in the next issue of our journal.*

*It is hoped that the Fair will reward the exhibitors for the great efforts they have made to provide a display representative of British industrial enterprise and achievements.*

**Birlec Limited** at the 1951 B.I.F. concentrated attention on their range of Lectrodryer equipment for the dehydration of air (particularly compressed air), other process gases and certain organic liquids. The interest was considerable and revealed unlimited possible applications which even Birlec experience (extending to over 3,000 installations) had not yet met. This policy will, therefore, be continued in 1952, three different examples of Birlec Lectrodryer equipment being on show.

Two of the units will be of the " dual-adsorber " type, that is, with two beds of adsorbent material operating in turn, so that whilst one bed is on drying duty, the other can be reactivated. Continuous drying service is thus afforded—the drying material, activated alumina, having a practically indefinite life.

The smaller of these dual adsorbers will be a model BY 1, rated to handle 75 cu ft of air per minute at a pressure of 50 psig. The compressed air is to be used for operating control instruments at an important new oil refinery in Great Britain. This dryer is one of eight ordered for this refinery, many identical and larger installations being on hand for similar projects. In the BY range of Lectrodryers, fully automatic, time-controlled valve operating mechanism is used—an important time-saver in a widely dispersed plant.

The other dual adsorber is the model BWC 150, designed to dry 560 lb of carbon dioxide per hour at a pressure of 220 psig for " Dry Ice " production. Whereas the BY unit will help to save dollars in a British refinery, the BWC 150 will be a direct earner of foreign exchange—as it is to be incorporated in a plant in India.

The third unit on the Birlec stand is a model CHE dryer for installation in a pharmaceutical plant in Brazil. The CH range of dryers is designed for controlling humidity in storage, processing and packing rooms or other enclosed spaces and finds application in many different industries. The CHE dryer exhibited will maintain a suitably dry atmosphere (at less than 20% relative humidity) in a small vial-filling cubicle.

Besides these three major units Birlec will also show a number of Lab-Lectrodryers—the small, single adsorber units used for intermittent drying duties in research or small production work. Pictorial displays and specially prepared literature will cover the large variety of applications which it would not be otherwise possible to exhibit.

The exhibits of **British Insulated Callender's Cables Ltd.** will be grouped into five main displays showing the Company's contribution to the generation, transmission and utilization of electricity. Cables and accessories will be shown under the main display headings of: Power Stations; Transmission and Distribution; Industries and Mines; Farm and Domestic; and Transport, including Ship, Automobile, Railway and Aircraft.

Exhibits will include the *Claw-type Cable Cleating System*, developed to satisfy the need for a universal assembly which can be easily built-up on site to suit new arrangements or re-arrangements of cables.

The cleats are mounted on suitable backstraps, either singly or in groups, for fixing to walls or steelwork for horizontal or vertical runs. The magnesium-free silicon aluminium alloy used is highly resistant to corrosion, allowing the system to be used in exposed positions.

A comprehensive range of cleats, studs and wall bolts will be shown, the different sizes being interchangeable.

*Consumer's Service Units* have been introduced to provide in one compact assembly all the supply equipment needed for any normal domestic electrical installation, including main fuse and switch up to 60 amps, meter connections and sub-circuit fuses.

*Bolted Flameproof Couplers* for use in mines allow cable joints to be made and sealed with hot-pouring compound above ground. They are equally suitable for use in quarries.

The range comprises half-couplers, tee assemblies, straight and right-angle adaptors, all of which have been certified flameproof by the Ministry of Fuel and Power.

*Detachable Fused Tee-Boxes* enable fused outlet-points to be economically installed, providing maximum flexibility for installation of additional plant. They also permit substantial economies in cabling.

Each equipment consists of (A) a cable chamber, fitted with either conduit glands, wood bushes or lead sheath and armour clamps, for insertion into a run of main feeder cable, and, (B) a fusebox, for attachment to the cable chamber, fitted with three high breaking capacity cartridge fuse links and arranged for a variety of both permanent and removable outlet connections.

The standard range is suitable for three-phase three-wire circuits up to 440 volts with main cables up to 0·15 sq. inch. Two sizes of fusebox offer maximum fuse ratings respectively of 30 and 60 amperes.

*The Pressure-Type Electric Vulcaniser* operates as a pressure mould ensuring complete amalgamation of the repair to the cable sheath. It consists of two half-cylindrical hinged shells—each containing heater elements—with dowels to ensure correct alignment when closed over the repair.

*The Copper Tape Electric Vulcaniser* is supplied either as a separate unit or as a combined repair bench unit. It is suitable for use on a.c. circuits and is self contained, comprising a transformer, controller and a thermo-couple-type temperature indicator. No liners, chamber or bath are required, so that the length of the repair and the diameter of the cable are not limited.

Among the other cables and accessories will be PBJ and House Service Overhead System cables with aluminium conductors; ship wiring and aircraft cables; mining cables including PVC insulated lightweight telephone cables; aluminium-sheathed cables; Mass-Impregnated Non-Draining Cables; HV cables; rubber and thermoplastic cables and flexibles; substation panels, fused tee-boxes and an 11kV straight-through joint.

# When Variety calls the tune!

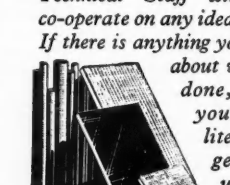
Playing up to the applause which comes our way from the experts, we present a picture of a lens-drying tray made of Tufnol which according to them more than comes up to scratch! For one thing it *doesn't* scratch, and that's important to optical glass; for another, it is unaffected by chemical action: two qualities not combined elsewhere.

Tufnol is, in fact, quite unlike any other material; yet it shares the virtues of many. The uses to which it can be put are of infinite variety! It is only half the weight of aluminium, yet structurally strong enough to work sympathetically with steel: it machines easily and accurately without splitting; does not warp; and is resistant to moisture and erosion. Added to these qualities is a high degree of electrical insulation. Supplied in sheets, tubes, rods, bars, angles, channels, or specially moulded shapes, Tufnol's astonishing versatility in use is the secret of its success!

*Tufnol is easily machinable with ordinary workshop facilities. Photograph shows a Tufnol gear being cut.*

**WHAT'S ON YOUR PROGRAMME?**

*Are you likely to have a new use for Tufnol, any time in the future? Our Technical Staff will be glad to co-operate on any ideas you may have. If there is anything you want to know about what Tufnol has done, we will send you appropriate literature. Why not get in touch with us TODAY!*



**TUFNOL**

REGISTERED TRADE MARK

An ELLISON Product

**TUFNOL LTD** • PERRY BARR • BIRMINGHAM • 22B

252

**The British Oxygen Company Ltd.** is exhibiting a complete range of cutting and welding blowpipes. For welding, the CH and DH models meet most requirements for general purpose and production work. The Cutogen 4, which is a combined welding and cutting blowpipe, will be shown as a complete outfit with welding heads for a wide range of work and a cutting head, to which nozzles can be fitted for cutting mild steel and cast iron in thicknesses up to 12 in. and 3 in. respectively.

For light welding and leadwelding there will be a range of oxy/acetylene, acetylene/air and air/hydrogen blowpipes. The Type ' O ' (oxy/acetylene) is suitable for welding light sheet in steel and aluminium, small diecastings and leadwelding.

The Cutogen models now ranging from Nos. 1 to 5 will be available for demonstration. No. 3 is a heavy duty blowpipe for cutting up to 20 in. in mild steel and 15 in. in cast iron. No. 5 is an outstanding general purpose cutter for cutting up to 12 in. mild steel and it can also be fitted with various heads and nozzles for hole piercing, rivet washing, gouging, powder cutting (for stainless steel) and powder washing (high-speed fettling of castings).

Of particular interest is the recently modified 36 in. Universal Cutting Machine which incorporates a new transmission, and a cutter designed for use with the B.O.C. one-piece nozzle. This enables the machine to be easily converted to powder cutting operation when profiling stainless steel.

The 55 in. Universal Cutting Machine now uses one-piece nozzles, and the modified P.S.L. (Portable Straight Line) cutting machine is fitted with two cutting heads, using one-piece nozzles for simultaneously cutting both sides of a strip.

Portable Welding Outfits, consisting of Blowpipes, Regulators and Oxygen and Acetylene Cylinders mounted on lightweight trolleys will be displayed.

Rods and Fluxes for welding, building-up and handfacing will be available for most ferrous and non-ferrous metals and the majority of alloys in both classes.

The Argonarc Process will be featured together with additional equipment which includes a Water Cooled Shield on the Mark III Torch for continuous heavy duty work. Demonstrations will be given on Aluminium Alloys, Magnesium and its alloys, Copper, Stainless Steel and Heat Resistant Nickel Alloys.

Free technical literature covering the many processes to which the equipment is applicable will be available.

**The British Thomson-Houston Company** features a correctly scaled reproduction, over 16 ft high and 14 ft diameter, of a 62,400-kVA vertical water-wheel alternator. Included are the stator, exciter, and thrust-bearing frame. Three of these BTH alternators have been manufactured for the new Los Peares Hydro-Electric Power Station in North-West Spain, and together with transformers, switchgear, etc., will be among the notable contributions that BTH is making for the generation of electric power, not only in Britain, but throughout the World.

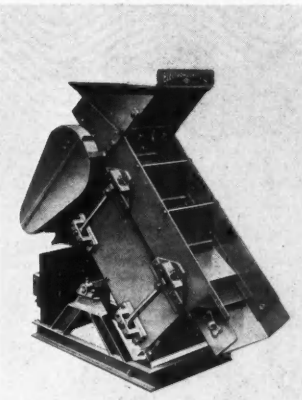
This exhibit forms an appropriate background for the display of BTH Electric Equipment for Industry, ranging from Switchgear for Industrial Power Distribution to Mazda Lamps and Lighting for all Industrial Applications. These exhibits are selected from the vast range of electrical equipment manufactured by BTH for Industry of every kind, and have particular reference to Industrial Rail Transport, Machinery Drives, Machinery Control, Industrial Processes, Industrial Heating, Research, and, as already mentioned, Power Distribution and Lighting.

**F. J. Edwards Ltd.** will exhibit a representative selection of machinery and hand-operated bench tools which will include eight new machines not previously shown at any exhibition. New metal-working machines will include a production model of the Mark II press brake, capacity 48 in. by 12 gauge, or 60 in. by 14 gauge mild steel; a heavy double geared universal swing beam folding machine, capacity 6 ft 2 in. by ¼-in. mild steel; a hand lever shearing, section cropping and notching machine with plate shearing capacity up to ½-in. mild steel; a wheeling and raising machine with 42 in. throat depth, and production bending rolls, type " E," size 36½ in. by 2 in.

New woodworking machines on show will include the Valjoh automatic self-feeding and self-aligning dowel and end forming machine; an overhand planing, jointing, rebating and moulding machine of 12 in. capacity, and a circular saw bench with 24 in. blade.

**Electromagnets Ltd.,** Birmingham, will exhibit a comprehensive range, including a lifting magnet, swarf separator, high-intensity chute-type magnetic separator, and various types of permanent magnetic separators.

Exhibits of particular interest will be :



A *Fully Enclosed* version of the recently developed *Boxmag* super-intensity electromagnetic conveyor head unit built into a short band conveyor unit. This magnetic head (patent applied for) has an intensity of magnetism three or four times greater than that of a pulley or drum of comparable diameter.

Fig. 1

A high-intensity heavy duty agitated chute separator, of the electromagnetic type (Fig. 1), for the removal of fine iron, feebly magnetic oxides and the like from powders and similar products which require agitation to ensure a free flow. The new coil systems give a separating power greatly in excess of that obtainable from previous magnetic chutes of this basic type.

Prototypes of new permanent magnetic separators greatly exceeding in strength any permanent magnetic separators hithertofore available. This will be known as the ' *Unimajor* ' permanent magnet, and will be of universal application for the removal of tramp iron and fine iron from food stuffs, free-flowing powders, grain, kibbled products, etc., etc., and it can be built up to any reasonable width in multiples of 6 in.

**The English Electric Company** will be exhibiting a typical Diesel Power-house layout, comprising a 4RK Mark II Diesel Engine with alternator and exciter, together with Type O.B.2 switchgear and Combination Fuse Switchboard; a comprehensive range of Fusegear; Unitised Switchgear Cubicles; Rectifiers including a 50 kW 550 V Mining-type unit; a 25 kW Induction Heater; a range of Industrial Motors and Domestic Appliances.

*The Power-House Feature* embraces a 4-cylinder naturally aspirated type ' RK ' Mark II diesel engine capable of a full load Output of 300 Bhp at 750 rpm together with alternator and exciter.

Special features embodied in the design of this range of engines include 4-valve cylinder heads, automatic shut down on failure of lubricating oil pressure,

*by* **B.O.C** *oxygen cutting machine*

Ten plates of mild steel cut and shaped in a single pass of the oxygen cutter . . . to identical measurements and with such a high quality finish that no subsequent machining is required. This operation—simple routine to the B.O.C 36″ cutter illustrated—saves time, labour and cutting gases, and permits quantity production to be carried on without loss of accuracy. *Apply to our local office for demonstration.*

***MAKE AND MEND WITH B.O.C MATERIALS, EQUIPMENT, SERVICE***

**THE BRITISH OXYGEN CO LTD**

*LONDON AND BRANCHES*

overspeed trip mechanism and universal bedplate suitable for industrial, rail traction or marine duties.

The ' RK ' Mark II range consists of five naturally aspirated and five turbo-pressure-charged engines from four to eight cylinders with outputs from 248 bhp at 600 rpm to 900 bhp at 750 rpm.

The exhibit will demonstrate the use of an O.B.2 type Air Circuit Breaker/Combination Fuse Switchboard for controlling and distributing the output from the Diesel/Electric Generator sets in a typical industrial setting.

*Fusegear Exhibit.* New developments will include a 1200 amps high-rupturing capacity Cartridge Fuse Link which has been A.S.T.A. certified to BS88-1947 for Category of Duty 440AC5 representing a rupturing capacity of 35 MVA.

The display will also include many types of H.R.C. Non-Deteriorating Cartridge Fuse Links together with examples of fusegear equipment designed to meet distribution requirements in Power Stations, Supply Undertaking Substations, factories of all types and buildings generally.

*Unitised Switchgear Cubicles.* A new design of control and relay cubicle has recently been introduced which is built on the unit system from standardised parts. This is a complete breakaway from the traditional welded construction from all aspects of manufacture and assembly. Instead of the frame, side and front panels being welded together, they are designed to form a bolted construction.

The shell comprises six separate components: front panel, 2 side panels, door frame, door and roof and, with the exception of the roof, are of folded construction, making for rigidity and strength. Along the folded edges and spaced at regular intervals are a series of punched holes on 2 in. centres. These holes, as well as being used for bolting the main components together, form the foundation upon which the internal fittings are built up by means of rolled ' C ' strips which may be used horizontally and vertically. Punched in the strip are OBA clearance holes and holes for speed nuts, spaced on alternate $\frac{1}{2}$ in. centres. Thus, utilizing the holes in the side and front panels, the ' C ' strips can be run horizontally on 2 in. centres and from them additional strips may be mounted vertically on spacings that are multiples of $\frac{1}{2}$ in. By this method the area can be fully covered and so permit the internal fittings and wiring to be placed in the most desirable positions.

Unitised control boards can be supplied to conform to all normal requirements; straight, horse-shoe pattern, corridor, pedestal and wall-mounted.

Unitised control desks are also being developed.

*Rectifiers.* The exhibits comprise single anode mercury pool rectifiers or excitrons. A 50 kW 250-volt mining-type unit employing six low voltage tubes will be displayed, " on-load."

Also a typical high voltage tube will be shown. Six tubes of this type will provide about 300 kW at voltages up to 15,000 d.c. Tubes of this kind are widely used for supplies to radio transmitters, H.F. heaters and other oscillator loads.

The new ' English Electric ' 25 kW *High Frequency Induction Heater* is robust and highly versatile for use in the production line. It uses a single air blast cooled oscillator valve made by the English Electric Valve Company, which eliminates the maintenance troubles inherent in water cooled valves. It is believed to be the most powerful H.F. Heater using a single air blast cooled oscillator valve.

The rectifier uses single anode mercury pool type valves, which are the most rugged devices available for this function. These valves are grid controlled for both power control and voltage stabilisation, making the H.T. supply virtually independent of mains fluctuations.

Apart from the fact that the equipment uses electronic technique in its design, it is engineered as a production machine. Facilities are available to enable applicators, work-handling gear or jigs to be mounted directly on the equipment.

The electrical features comprise H.T. voltage and output impedance matching, continuously variable over wide limits, and also facilities for providing the kVA/kW ratio suitable to the applications. Electrical and mechanical interlocks are provided for the protection of personnel.

A new range of ' English Electric ' standard motors will be shown for the first time.

**The General Electric Co. Ltd.,** will tell the story of the Company's Research Laboratories, the tools they use, the results they achieve, and their function within the Company's large manufacturing organization.

A spherical integrating photometer unit, one metre in diameter, will be shown in operation. The photometer (Fig. 2) is used for the accurate measurement of light output when new or experimental light sources are developed and for calibrating commercial photometers with which the lamps manufactured by the Company are tested.

Fig. 2

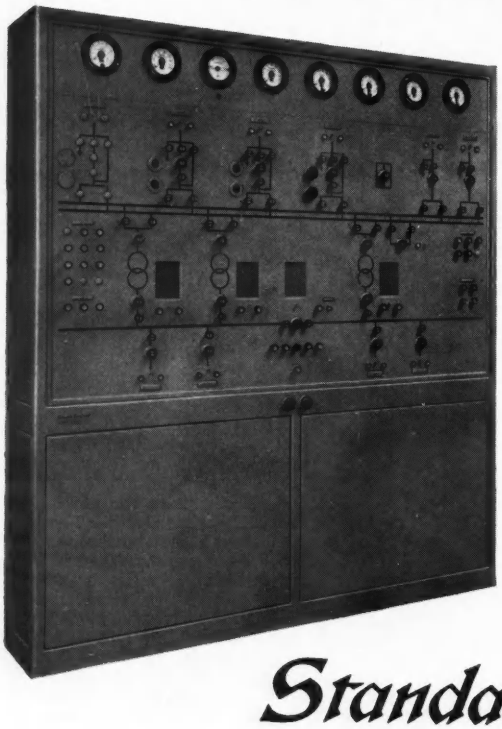
The most convenient method for measuring the total light output of a lamp, that is, all the light emitted at one time in all directions, is to operate the lamp at the centre of a hollow sphere having a matt white inner surface. A property of such a sphere is that the brightness of a small area of the inside surface, screened from the direct light from the source, will be proportional to the light output of the lamp. A translucent window is fitted in this small screened portion of the sphere wall and is measured for brightness from the outside of the sphere. In the demonstration, specially developed photo-electric apparatus will be used for making this measurement.

A test set for making measurements on groups of turbine blades will also be shown in operation. Steam turbine wheels and their associated blading are subjected to periodic force which may cause dangerous wheel and blade vibrations to build up under certain conditions. Once the frequency characteristics of the various types of wheels and blades have been determined, however, it is possible to avoid any major resonances by careful design. The equipment shown is used for such measurements. Installed in the Turbine Research Laboratory at the Fraser and Chalmers Engineering Works of the G.E.C., Erith, Kent, it is also used for some of the many precautionary routine tests carried out on fully-bladed wheels before they are put into service.

# *is the job at your fingertips?*

IT IS if you're a control engineer with *Standard* Supervisory Remote Control to bring a whole string of substations under your fingertip command. Generators, transformers, switchgear . . . indeed, all the circuit elements which make up modern generation and distribution systems can be controlled from one central board with speed and certainty.

Centralised supervisory systems using coded impulse trains have been designed especially for use where pilot lines are scarce. Such systems, developed and pioneered by *Standard*, are fully safeguarded by the "Constant Total" feature which positively prevents maloperation if, for example, signals should happen to be mutilated by induced voltages or by any other cause.



**Supervisory control cubicle** for the remote control of a large 132-kV switching station. Facilities include metering, synchronising, transformer tap control, circuit breaker control, isolator indication, alarm indication, protection trip reset. This equipment was supplied to the B.E.A. North Eastern Division.

# *Standard*

## Supervisory Remote Control Systems

*Standard Telephones and Cables Limited*

*Registered Office : Connaught House, Aldwych, London, W.C.2.*

**TELEPHONE DIVISION:** OAKLEIGH ROAD, NEW SOUTHGATE, N.11

Fig. 3
**Vacuum physics exhaust pump tables used in photocell development.**

A vacuum pump system will be shown to illustrate the application of physics in industry. The particular system to be operated is capable of giving an ultimate pressure equivalent to one millionth of a millimetre of mercury. Once the tube or other device to be evacuated has been attached to the pump system, it is baked in an oven at 400° C to drive off and remove gas absorbed on the glass and metal components. This baking schedule for the purpose of "outgassing" is always incorporated in the manufacture of any vacuum device.

One such device is the mercury isotope electric discharge lamp, the story of which is told in a series of photographs. The mercury isotope 198 is produced by the bombardment of gold with neutrons in the interior of the atomic pile at Harwell. It is possible to distil this artificially produced mercury isotope from the gold foil by heating, and the mercury which is driven off in this way may be transferred to the discharge tube. The purity of the spectral lines obtained from this discharge leads to the attainment of an increased accuracy in length measurement by interference methods using such lamps. The separation of the single mercury isotope 198 and its use in a discharge lamp for interferometry greatly improves the sharpness of the fringes in the resulting interference pattern. It is believed that the increased accuracy obtained in this way will shortly lead to the definition of international standards of length in terms of light waves.

The thermionic valve and a valve vibration machine will be shown to illustrate techniques used in research to improve the life, performance and reliability of this important device. Miniature type radio valves are life-tested under conditions of artificially induced vibration of high frequency. The valves, twenty-four of which may be tested at a time, are held in V-blocks which are cut in a vertically mounted tubular carriage. This carriage is supported by wires, and simple harmonic motion is produced by a moving coil motor, the coil being mounted directly on the lower end of the carriage. Electrical and optical monitoring of the motion of the carriage is employed. This machine can be operated in the frequency range 50 to 5000 cycles per second and at a maximum acceleration of approximately ten times that of gravity. In the design of these machines, particular care is taken to ensure that all the valves on vibration life-test undergo the same motion.

A display shows the part played by the G.E.C. Research Laboratories within the Company's organization as a whole and demonstrates clearly that every manufacturing unit or technical department in the Company requiring scientific advice is represented by a group of workers in the Laboratories. Four actual exhibits chosen to represent products of G.E.C. research, are: cold pressure welding, turbine supervisory equipment, microwave circuits, and diamond wire-drawing dies.

The cold pressure welding process was developed in the G.E.C. Research Laboratories in 1946. It has created world-wide interest as a new metallurgical technique as it enables metals to be joined by means of a homogeneous weld produced solely by pressure at room temperature.

Equipment designed by the G.E.C. Research Laboratories indicate and record three measurements in connection with steam turbines. The equipment includes three sets of detector coils which are placed inside the turbine, one to measure axial displacement, one to measure vertical eccentricity and displacement and the last to measure horizontal eccentricity and displacement. Any distortion that may occur can then be read off on the instruments, giving a clear picture of these distortions taking place in the turbine while actually running. An experimental equipment will be exhibited to demonstrate the principles involved.

Much work has been carried out by the G.E.C. Research Laboratories on the transmission of information by means of a chain of unattended radio relay stations. One of the latest projects along these lines is the design of a universal radio link, which, when completed, will be capable of transmitting television, audio telephony, carrier telephony, telegraphy or facsimile signals.

Such radio link equipment is in hand for use on the 2000 Mc/s frequency band, assigned by the Atlantic City Conference for such purposes. Samples of some radio frequency circuits for use in this band will be shown on the stand. As in the case of circuits used in the London-Birmingham Television Radio Relay Link, installed to provide simultaneous two-way transmission frequencies of approximately 1000 Mc/s, the characteristics of these circuits are derived from resonant co-axial lines and depend on precision mechanical engineering.

The fine tungsten and molybdenum wires required for lamp and valve filaments are most easily drawn by using diamond dies. Owing to the hardness of these metals, the use of most other materials for making the wire-drawing dies would lead to excessive shortening of the life of the dies.

Six enlarged cut-away models of a typical diamond die will be shown to illustrate the different stages in the production of such a die.

It is hoped to show a selection of cathode ray tubes, Geiger-Mueller counters, crystal valves, photocells, vacuum condensers, magnetrons and U.H.F. valves, in the development of most of which the Research Laboratories played a leading part. Again, materials produced as a result of extensive research work, including G.E.C. Heavy Alloy, synthetic quartz, synthetic sapphires and special refractories will be shown. Special laboratory lamps, fluorescent lamps and compact source lamps will also be displayed.

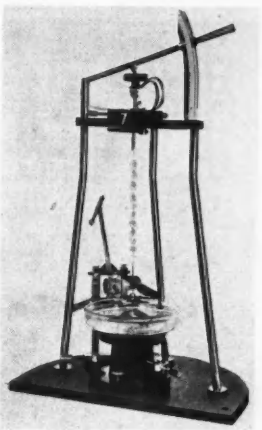
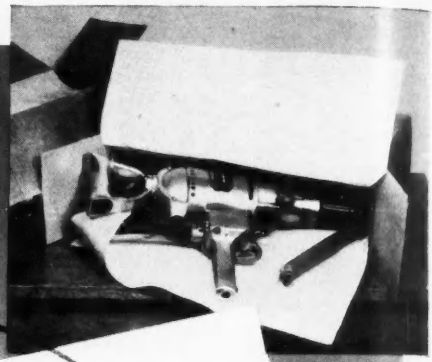


Fig. 4. **Production unit for diamond die piercing by electric arc.**

**The Goodyear Tyre and Rubber Company** will demonstrate the maintenance of quality control at every stage in the manufacture of conveyor belts and hose.

Each of the three main groups of products—Conveyor Belting, Wrapped Ply Hose and Braided

"Economical efficient ..... we intend to use V.P.I. paper in all.... our packing"



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DATE 27th August, 1951.

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Hose—of the Wolverhampton factories of the Goodyear Tyre and Rubber Company will be included in the demonstration. A series of transparencies automatically illuminated in succession will show the efficiency of Goodyear's high standard of quality control. Each panel will show a stage of manufacture, a close-up of the test applied at that particular stage, and some explanatory copy as to what is being done and why.

The centre piece on the foreground of the stand will display the range of Goodyear Conveyor Belting. The Conveyor Belting range will be flanked at the left by a model of Rayon 'V'-belt and mounted examples of Cord 'V'-belt. On the right of the central display will be an enlarged cut-down section of hose treated in a similar manner to the rayon 'V'-belt. The hose display will be backed by a series of short samples of different types of hose arranged so that each can be easily examined. On the front of the stand, mounted on this display piece, will be a section of Rotary Hose.

A panel showing the Endless Cord Transmission Belt, with rolls of other types of Goodyear Transmission Belting, will also be displayed.

**The Hymatic Engineering Company Ltd.** will be showing a full range of the latest pneumatic equipment.

A sturdy new compressor unit, the 100 SAS, is designed for fitting to agricultural implements, motor vehicles, machine tools and so on, as initial equipment or as an optional extra. Displacing 7·5 cu ft of air per min. at pressures of 80-100 psi, the 100 SAS has the performance necessary for spray painting, lime washing, insecticide spraying, pneumatic greasing, tyre inflation, pneumatic braking, the operation of air tools, controls, jigs and fixtures and other compressed air applications. Absorbing only 1·34 hp at 2000 rpm when delivering its full capacity, this versatile compressor weighs 36 lb complete. It can also be supplied in bulk to other manufacturers for incorporation in their own products.

Another compressor shown is the TMS14, a larger unit developed for direct mounting on most of the popuar makes of tractor. With a displacement of 13-14 cu ft per min. at working pressures of up to 100 psi, this twin-cylinder, air-cooled unit is belt-driven by the tractor pulley, the diameter being so arranged that the engine runs at a moderate speed, thus conserving fuel and increasing efficiency. The compressor can be fitted in less than half an hour.

The main exhibit will consist of stationary and mobile compressor sets for general purposes. The stationary range, covering displacements from 5 to 22 cfm, will be represented by the electrically driven 'G' and IS.10X models, both of which are particularly suitable for garages, workshops and small factories.

The novel Hymatic DP6 electrically driven diaphragm type compressor has been developed to supply compressed air completely free from oil vapour or other impurities for such duties as food processing, raising liquids, and for special applications in scientific fields. All mobile compressor sets and the Pressure Feed Containers will be fitted with the Air Rectifier type R50 which removes oil and water vapour from the air supply and provides an accurate control of the pressure.

Four Hymatic air hammers will be shown—the PH107 and 108 pistol-grip models and the heavier duty PH113 and 114 with their spade type grips. The tools available for use with these implements include flat, cross-cut and routing chisels, planishers, metal-cutters and scrapers.

**Keelavite Rotary Pumps & Motors Ltd.,** Coventry, exhibiting on Stand No. D612, specialise in Hydraulic Power Transmissions and cover the whole field of Applied Hydraulics.

In a working exhibit, fluctuating and out of balance loads are applied to a hydraulic motor shaft by a steel ball weighing 2¾ cwts.; the loads are completely absorbed by a dynamic braking valve which maintains a constant speed of rotation.

A further exhibit of interest is the new Keelavite fully balanced, high-pressure gear pump (Fig. 5). A single

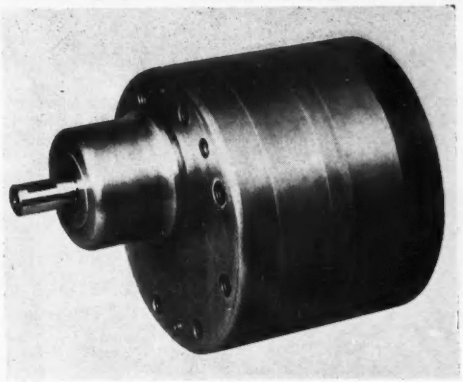

Fig. 5

stage unit, the pump develops a continuous working pressure of 2,000 psi and, at that pressure, is as quiet as a conventional electric motor. This remarkable performance is due to the Keelavite, World patented, hydraulic balancing system which eliminates the need for rubbing plates, prevents axial and radial displacement of the gears and ensures volumetric efficiencies reaching 95% even after prolonged periods of heavy duty. The pump has an integral belt drive adaptor and can be driven by a pulley mounted directly on the pump shaft.

The remainder of the exhibits are selected to illustrate the wide range of Keelavite hydraulic drive components and to demonstrate the high power-weight and power-space ratios of Keelavite Hydraulic Motors.

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In displaying simultaneously the mutual effect of two related and variable quantities the Cossor Double Beam Oscillograph is solving many of the fundamental problems with which the Research and Development scientist is constantly beset. In addition, workers in every branch of Industry are realising the infinite uses of this instrument in the detection and analysis of faults and the accurate monitoring of manufacturing processes.

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In Models 1035 and 1049 the two traces are presented on a flat screen of 90 mm. diameter and the amplifiers and time base are so calibrated that measurement of the voltage input as well as the time interval between various significant portions of the oscillogram is made possible. Permanent records of these traces for subsequent analysis may conveniently be made by attachment of the Cossor Model 1428 Camera.

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# SWISS INDUSTRIES FAIR, 1952

*High-quality machine tools, electrical equipment and instruments of Swiss manufacture are playing an increasing part in the rearmament programme of the Western World. Trends and progress of the Swiss manufacturing industries can be observed at the Swiss Industries Fair which will be held from the 19th to 29th April at Basle.*

*Our Editors have visited in recent weeks numerous Swiss technical establishments, factories and research laboratories. As a result of these visits, we are able to publish advance information on some of the latest developments and products to be shown at the Basle Fair.*

Among all the machine tools to be exhibited, major new developments appear to be mainly confined to special-purpose machines, and only to a lesser degree are new features noticeable on standard general-purpose machine tools.

A special high-precision lathe for the production of accurate leadscrews (Fig. 1) will be shown by REISHAUER TOOL WORKS LTD. of Zurich, the well-known makers of thread and other precision grinding machines. Many of the features normally found on lathes are omitted, and the bed is specially strengthened to ensure rigidity and maximum accuracy. The 3-in. diameter master leadscrew, which is of extreme precision, being hardened, ground and lapped, is accommodated in the centre of the bedways and is thus protected. Several drag bearings support this leadscrew at intervals to prevent deflection due to its considerable length. For maximum precision, the leadscrew is manufactured in several short sections, and these are assembled using a special patented method. The machine can be set to cut left- or right-hand threads. The two fixed steadies have hardened bearing plates and these are automatically lowered by hydraulic power before the approach of the slide; in addition, there is another steady fitted with interchangeable guide bushes and this is attached to the slide in the close vicinity of the cutting tool. Maximum precision is ensured by two independent pitch-correcting devices. One of these corrects irregular pitch errors and uses a template placed in the lathe bed. The correcting motion is transmitted to the slide by a lever. The other device, consisting of a double differential wheel, corrects regular pitch errors down to 0·0012 in. over a length of 40 in. Leadscrews of 80 in. and 140 in. length can be produced on the two available sizes of the machine; their diameters can range from 1 to 3 ins. Extremely high precision is claimed for the machine, providing that the leadscrews are rough-machined on other machines and the leadscrew lathe is used only for finishing.

Another lathe, of a totally different type, which has recently undergone modification and considerable improvement is the SIG Copying Capstan Lathe, made by the SWISS INDUSTRIAL COMPANY of Neuhausen. It now has two turret heads, one of them being placed on the cross-slide. Each of them can accommodate six tools, so that a total of twelve tools can be used in one set-up. Magnetic clutches are now incorporated for gear changes and reversal of spindle rotation, and the driving motor power has been increased from 2 hp to 2·5/3 hp. The machine is well suited for copy turning of small or medium batches and virtually bridges the gap between normal centre lathes and automatic lathes. Another new feature is a thread cutting attachment. Collets up to 1·44 in. dia. and a three-jaw chuck with a 1·6 in. bore can be used, and operations including drilling, reaming, external and internal thread cutting and knurling can be performed.

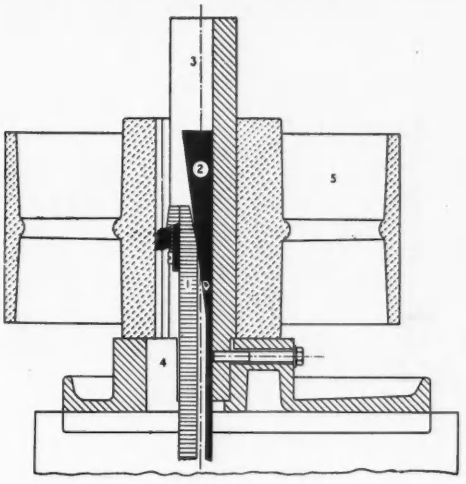


Fig. 2

The basic principle used in the operation of the MAC Keyseating Machine exhibited by VIAL & RITSCHARD, Geneva, is of considerable interest. (Fig. 2). A vertically reciprocating cutter bar (1) and feed wedge (2) are accommodated in a stationary, hollow guide bar (3), which is firmly attached to the machine table (4). This guide bar is inserted in the component (5) bore for location and holding purposes

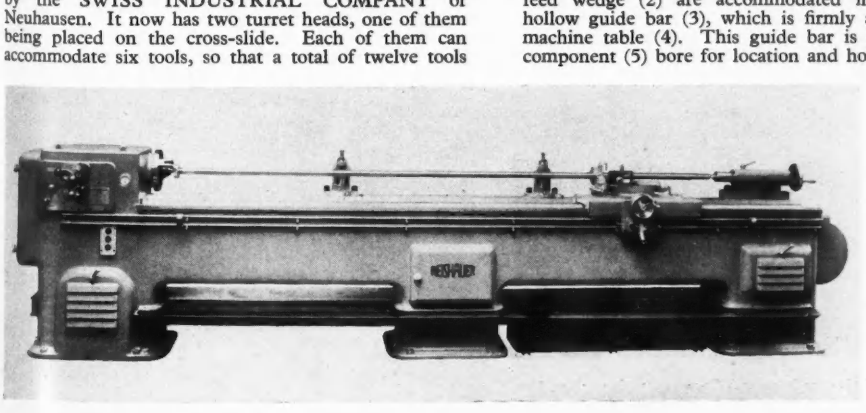

Fig. 1

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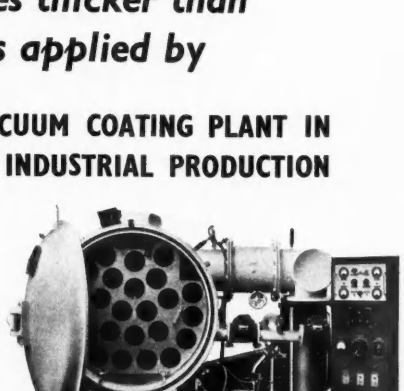
which produces low absolute pressures down to $10^{-5}$ m.m Hg, evaporates and deposits aluminium and other metals on plastic, paper, metal and other objects in film thicknesses of approximately 0·000005". Scarce and expensive materials thus 'go much further' and superior finishes are obtained very economically. Typical products processed in B.A.R. High Vacuum Coating Plants are bloomed lenses, coated mirrors, reflectors and plastic jewellery. The illustration shows the type 3130 Evaporator with 50 cu. ft. capacity tank, cycle time being 15 to 20 minutes.



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The cutter bar is automatically fed by the feed wedge at its rear. In addition to the reciprocating motion, the feed wedge performs a small additional downward movement at the commencement of each stroke, thus actuating the progressive in-feed of the cutter into the keyway. The required keyway depth is pre-set and the machine cuts out automatically on reaching this depth. The cutter is automatically relieved for the return stroke to avoid unnecessary wear. The three-sided location of the cutter bar in the guide bar ensures straight keyways as it prevents deflection. The machine incorporating this principle is said to be very economical in operation and highly efficient. For example, a keyway 15 in. long and $\frac{5}{8}$ in. deep can be cut in a steel component in about 10 min., using a feed of 0·003 in. per stroke. A number of workpieces with identical bore and keyway dimensions can be placed on top of each other and the keyways can be cut at one setting. Exceptionally long keyways and splines can also be produced, using special attachments. Another great advantage of this type of machine is the unlimited outside diameter of the component as there are no interfering obstructions, the component being only located by the guide bar and stepped or expanding bushes in the bore.

Among the small precision machine tools, specially designed for fine instrument, optical, watch and clock manufacture, a universal machine tool by SCHULER & SONS, Zurich, was noticed. This machine tool has recently been redesigned and improved. It is capable of performing an astonishing range of machining operations, including turning, drilling, milling, grinding, circular and fret sawing and thread cutting. Its main application will be for "one off" or small batch production, as in such cases it replaces a number of normal machines. Several features, however, render it also suitable for continuous production. For example, among the wide range of accessories there is a turret head with eight individual tool positions (Fig. 3). These can be equipped with turning tools, drill chucks, die heads, etc. The machine occupies a space of only 26 in. by 10 in., and as an indication of its capacity, the following maximum values are quoted by the makers: turning diameter $3\frac{1}{2}$ in., drilling in steel up to 0·2 in., grinding wheel diameter $2\frac{3}{8}$ in.

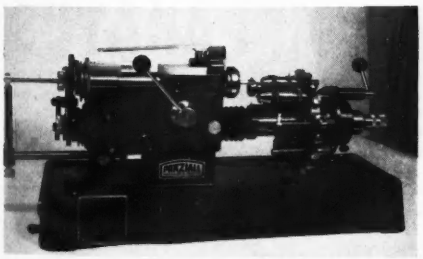


Fig. 3

In the field of specialised precision machine tools, the SOCIÉTÉ GENEVOISE dividing machine for milling and drilling will be another outstanding exhibit. It is intended mainly for the machining of bars and other parts of knitting machines requiring a large number of very accurately spaced slots, notches or holes. A precision dividing mechanism working to an accuracy of 0·0005 in. drives the table which slides on vee and flat scraped ways. In addition, the table is mounted on sprung rollers moving on auxiliary ways, so that the load on the guide ways is decreased, reducing the wear to a minimum. The drilling and milling heads are interchangeable, and up to four individual heads can be used for simultaneous operation. They employ high spindle speeds for maximum utilization of carbide and H.S.S. tools and cutters. This attention to rapid operation results in high production rates. For example, twenty holes of 0·02 in. diameter and 0·08 in. deep can be drilled in one minute in a brass component; alternatively, twenty slots 0·008 in. wide, 1 in. long and 0·08 in. deep can be milled in one minute in a similar component. The machine incorporates numerous other refinements such as a compensator for the difference in thermal expansion between the leadscrew and the part to be machined. The scale for this is graduated in 0·05 per thousand in length and is essential for precision work if the ambient temperature differs appreciably from the standard calibrating temperature of 68° F. The working surface of the table is $41\frac{1}{2}$ in. by $7\frac{7}{8}$ in. with a travel of $40\frac{1}{2}$ in.

Several detail improvements were also apparent in the LWB Automatic Hack Sawing Machine produced by KIENER & WITTLIN, Berne (Fig. 4). This pre-

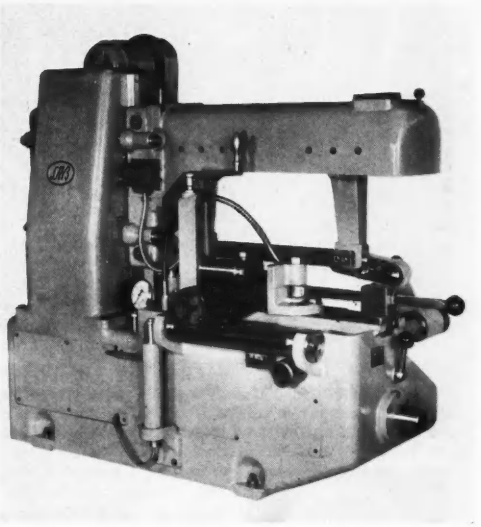
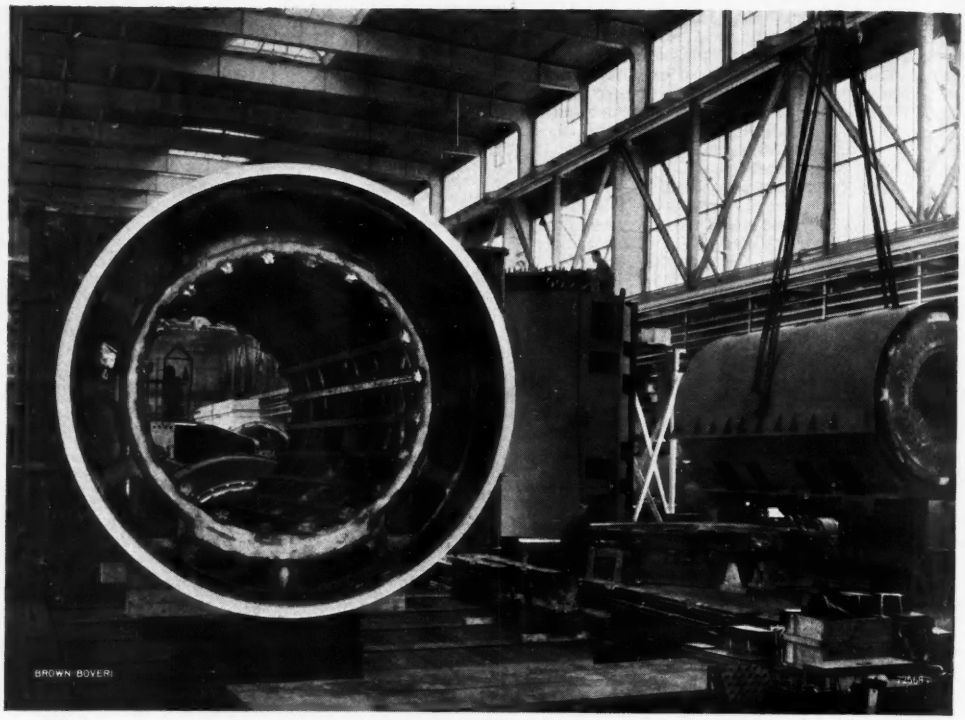


Fig. 4

cision-built hydraulic machine has a fully automatic feed adjustable up to 20 in. and working to a tolerance of some 0·013 in. A refinement towards full automatization is a component counter, so that the machine can be pre-set to cut off a given number of components after which it will stop automatically. The saw blade is automatically lifted for the return stroke up to 0·4 in. above the cut and the sawing pressure is automatically adjusted to the cross-section being cut. A hydraulic work-clamping vice incorporates a pressure gauge in its circuit and the clamping pressure can be varied within wide limits to suit very heavy cuts in solid material down to thin pipes or profile sections.

A Christen drilling machine, which will also be on show, utilises a new type of stepless speed variator giving the unusually wide speed range of 70 to 7000 rpm in two steps. This feature becomes very important when the machine is used for continuous quantity production. It is known that, under certain conditions, drill life is critically dependent on cutting speed and under these conditions a small increase or lowering of the cutting speed may affect drill life to a very great extent. It is therefore important that the speed should be selected carefully, but on normal geared machines it may well happen that the available speed steps are either well above or below the required speed. Thus, a steplessly variable drive affords the




**Stators of Large 3000 R.P.M. Turbo-Generators under Construction in the Brown Boveri Workshops.** On right, slung from the crane, the stator frame of a 62500-kVA generator complete with laminations; in centre, on end, the stator of a 80000-kVA machine in course of winding; in left foreground, the fabricated stator frame of a 125000-kVA unit.

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facility of accurate speed selection, resulting in an optimum compromise between production rates and drill life. These neatly designed machines are made in a range of sizes for bench or pillar mounting and can be provided with a reversing gear for tapping.

Another case of an interesting design feature in a machine tool, in a totally different category, is a high-speed blanking press, which uses the upstroke principle (Fig. 5). The makers claim that in a conventional press

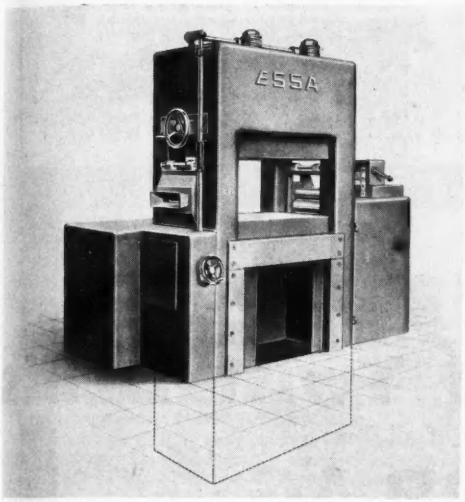



Fig. 5

working downwards causes undue wear on stamping or punching tools due to the excessive penetration of the punch into the die. This excessive penetration is inevitable with conventional presses, as clearances have to be provided for the working parts. These increase with time due to gradual wear. During the working stroke, the total effect of these clearances is excessive tool penetration into the sheet metal being punched and into the die. This causes wear, and in the case of the increasingly popular sintered carbide tools it may cause complete breakdown. With the new press design, however, the excessive penetration due to clearances is eliminated as the stamping members have no vertical clearance and will not develop any. Other useful features of the machine include the possibility of using very short strokes down to about 0·12 in. for very thin sheet, a precision roller feed mechanism the rollers of which are mounted in ball bearings, and adjustable speed obtained by the use of a shunt system, a variable belt pulley or, alternatively, a pole changing induction motor. Among the advantages of this press, which is manufactured by ESSA of Brügg—Bienne, the following are claimed: minimum tool wear, no deformation of the stamped part, high rate of output with no danger to the operator, and noiseless operation.

A new method of cementing diamonds to the base matrix is used in the production of tools by DIAMETAL A. G. of Biel. It is claimed that the method enables diamond particles to protrude considerably from the matrix and yet be retained firmly. The range of diamond tools covers a variety of internal grinding shapes, including discs up to 1 in. dia., as well as hand and machine files, circular saws and trepanning tools.

The accurate grinding of twist drill points is only possible on suitably designed machines, which should be constructed so as to allow the grinding of various point angles and relief angles. The importance of the relief angle becomes apparent when it is appreciated that it is the equivalent of the clearance angle on a turning tool and, as such, affects the strength of the cutting wedge and the life of the drill. A range of such machines is produced by METEOR A.G., Zurich. The smallest machine (Fig. 6) is capable of grinding twist drills of between 0·008 in. and 0·120 in. diameter. It incorporates a special microscope for the accurate inspection of the twist drill point being ground. Two larger machines extend the range of drills that can be dealt with up to 3¼ in. An important feature of all these machines is the simple, foolproof operation.

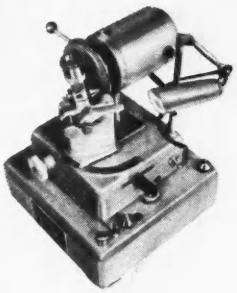


Fig. 6

The same manufacturer also produces a special twist drill web thinning machine for drills between 0·32 in. and 3¼ in. diameter. The machine produces accurately spaced web thinning grooves and can also be used for correcting the flute face adjacent to the cutting edge. The use of such a machine avoids inaccurate web thinning, which may be valueless or even detrimental to drill life and hole accuracy.

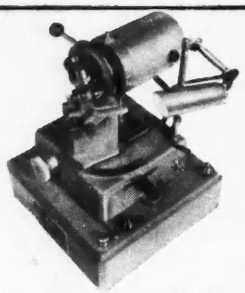
A precision measuring instrument for gauging bores, without the necessity of withdrawing the boring bar, has been recently developed by the firm OTTO HAEHNLE, Exacta Measuring Instruments, Zurich. The same firm will show a variety of precision instruments for bores, external diameters, lengths and profiles, a height setting gauge for milling and drilling machines, an internal measuring gauge for deep measurement, with a retractable feeler, and a measuring gauge for engine cylinders.

Electronic controls, covering the entire range from extremely small powers to maximum powers, will be shown by BROWN, BOVERI & CO., of Baden. New developments include a 1000-hp d.c. motor for rolling mills, which is produced as a "block" unit incorporating a transformer and a converter for supply from a three-phase network. The thyratron control unit is built in a small easily removable frame and controls motor speed with an accuracy previously unattained in rolling mill practice.

For low powers, an electronic impulse controller is shown, which controls, for instance, the small speed fluctuations occurring in three-phase shunt commutator motors when the load is varied.

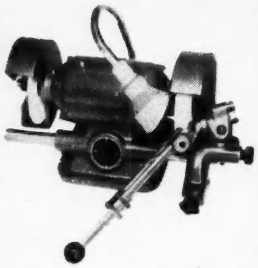
Fig. 7

Two new low-voltage switchgear installations will be shown. The first is a push-button-actuated protected switch for small motors taking up to 10 amperes. The operating parts are assembled without threaded connections. The second set is a compact distribution cabinet with removable automatic switches designed for the range 4000-1500 A.



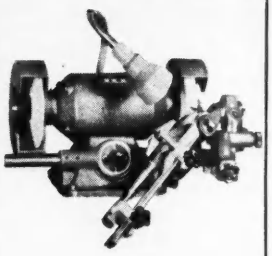
Twist Drill Grinding Machine Type KBS. Drill Capacity 0.2-3 mm. ϕ (0.008"-0.12")

KBS



Twist Drill Grinding Machine, Type A. Drill Capacity 2-15 mm. ϕ (0.08"-0.6")

SBS – A



Twist Drill Grinding Machine, Type B. Drill Capacity 12-30 mm. ϕ (0.47"-1.18")

SBS – B

# Sharpening and Web Thinning of all Twist Drills

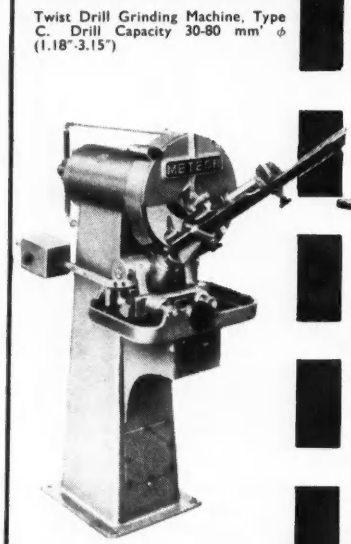
and Sharpening of all Taps

## METEOR AG

**ZURICH, Dufourstrasse 182/188 Switzerland**

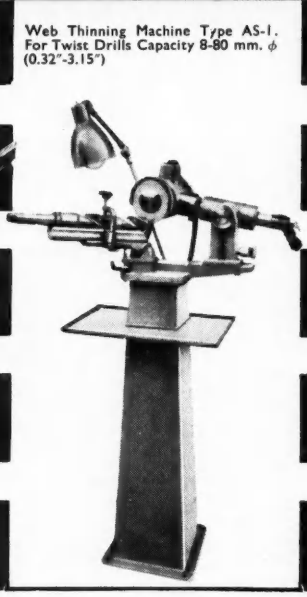
SBS – C

Twist Drill Grinding Machine, Type C. Drill Capacity 30-80 mm' ϕ (1.18"-3.15")



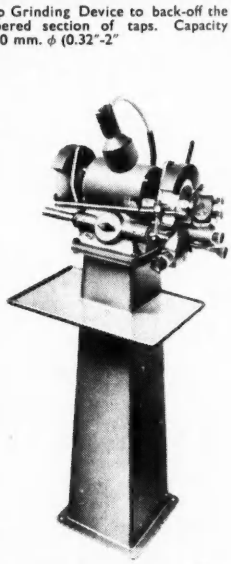

AS – 1

Web Thinning Machine Type AS-1. For Twist Drills Capacity 8-80 mm. ϕ (0.32"-3.15")



GBS

Tap Grinding Device to back-off the tapered section of taps. Capacity 8-50 mm. ϕ (0.32"-2"



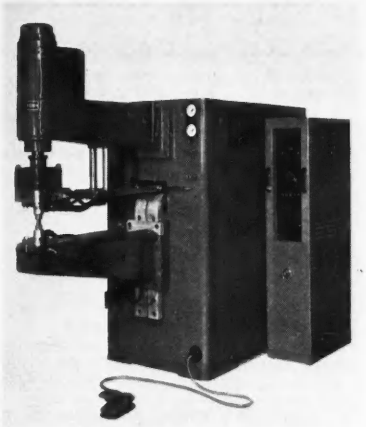


Fig. 8. **Pneumatically operated spot-welding machine for mass production of instrument parts. (Brown Boveri & Co.)**

New transmitter triodes of 400 and 1040 W output have been produced. For higher powers, short-wave triodes with thoriated tungsten cathodes have been built, with anode powers of 1, 2 and 6 kW for the frequency range of 110-200 megacycles.

A Betatron tube is the principal component of the Brown Boveri 31 MeV radiation transformer, in which the electrons are accelerated up to a velocity nearly equal to the velocity of light, and then decelerated suddenly, so as to obtain an ultra-hard X-ray radiation.

Fluorescent lighting in railway carriages is now possible using the standard a.c. fluorescent lamps, with the aid of a new converter unit, in which the generator is driven from the carriage axle by means of bevel gears and a cardan shaft. The fluorescent lamps are supplied at constant voltage and frequency by means of the new railway lighting control unit, in spite of the variable load.

Brown Boveri will also show 4 and 25 kW high-frequency generators for induction hardening. The smaller model includes an automatic feed device for short steel bars which was developed by TAVARO S. A., of Geneva. Machines covering the entire field of electric arc welding, will also be shown. Nearly all the spot-, seam- and butt-welding machines shown are provided with the latest electronic devices for accurate control of the welding process.

Transformers with windings embedded in a new shock-proof insulating mass are being built by MASCHINENFABRIK OERLIKON of Oerlikon-Zurich. Among these is a current transformer for working voltages of up to 400 kV, the active part of which is made of this hardenable insulating mass.

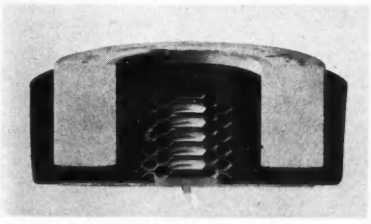


Fig. 9

The good insulating and thermal conductivity properties of the new insulation have made it possible to reduce transformer dimensions. A further advantage of the synthetic resin insulation is its incombustibility. Overvoltage suppressors, also produced by means of the new insulating technique, are characterised by a very low height obtained by a suitable arrangement of the quenched spark gaps and voltage-dependent resistors cast in the mass.

A new safety control unit for traction vehicles automatically stops a train when the driver is not able to operate, even when the safety pedal is in the depressed position. The apparatus supervises the activity of the driver and works only if he is inactive. The safety device is set to operate after a period of time which is considered necessary to cover a certain distance. If, within this period, the driver has operated the steering controls, the brakes, the pedal or a pressure button, the safety device returns to its initial position and the cycle commences again. The driver can reset the apparatus to its initial position by pressing a button. If no such operation is performed, the apparatus will switch out the traction motors and start the emergency braking. The time period is selected in such a way that normally the driver has to effect an operation before the end of each period, so that no additional load on the personnel is involved.

TRÜB, TÄUBER & CO., of Zurich, have developed a new space-saving switchboard instrument with a square casing of 110 × 110 mm. The scale extends over an angle of 250 deg. and thus gives a scale length of about 160 mm. This scale length with a 90° scale would require a casing of about 270 mm diameter for a cylindrical instrument. The meter can be supplied for all applications, i.e., as a voltmeter or ammeter (d.c. or a.c.), as a frequency meter, synchronoscope, wattmeter, phasemeter, or remote-indicating instrument.

A new recording instrument has two styluses arranged at the top and on the front side of the instrument. They move in conjunction with pointers showing instantaneous values on a graduated scale situated above them. The ink feed is easily accessible.

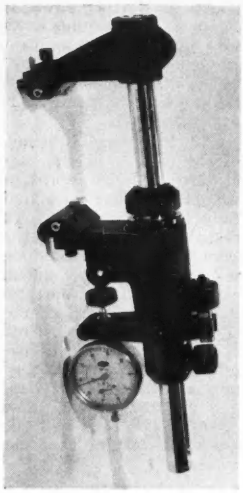
A " disturbance recorder " registers the duration of short-time disturbances in a network, such as occur in earth connections or short-circuits. It is characterised by an extremely rapid response, the time lag between the initiation of the disturbance and the commencement of recording being about 0·04-0·06 second. An additional delayed-action filter delays the disturbance by about 0·05 second, so that the beginning of the disturbance can also be recorded. The paper speed is 80 mm per second and a measurement accuracy of 6 per cent is obtained.

A portable recording instrument also produced by this firm uses a special paper and requires no ink or ribbon for the recording of rapidly varying quantities.

A new electron microscope, type KM4, to be exhibited has the following features :—Short overall length, with three image lenses, two of which can be swung out of the field (the static objective lens and the magnetic projection lens). This makes it possible to obtain a wide range of magnifications. The new focussing device is the subject of a patent application and, for photographic work, an interchangeable box for five plates and a film box are provided. The preparation lock is designed with a pre-evacuating arrangement, so that the work can be carried out practically without interruption. The resolving power is 25-50 Angstrom.

The SWISS LOCOMOTIVE & MACHINE WORKS, of Winterthur, have developed a capacitive pick-up for torsional vibration measurements. The pick-up is used with a pre-amplifier and a cathode-ray

# EXACTA Mechanical Precision Measuring Instruments



**Type BK** **For gauging bores, without the necessity of withdrawing the boring bar.**
*Range:* Size I—0.79 ins. to 4.72 ins. Size II—1.78 ins. to 19.69 ins.

**Type STM** **For bores, external diameters and lengths, using a micrometer.**
*Range:* 20 ins. to 2000 ins.

**Type STU** **For bores, using a dial gauge.**
*Range:* Size I—4 ins. to 12 ins. Size II—8 ins. to 20 ins.
Size III—10 inches to 40 ins.

**Type WAMK** **For external diameters and profiles, using a dial gauge.**
*Range:* 8 ins. to 60 ins.

**Type EB** **Special setting gauge.**
*Range:* 0 to 4000 ins.

**Type HE** **Height setting gauge for drilling, milling and other machines.**
*Range:* 1.25 ins. to 50 ins.

**Type IM** **Internal measuring gauge for deep measurement, with a retractable feeler.**
*Range:* Size I—1 in. to 3 ins. Size II—2 ins. to 12 ins.

**Type AC** **Engine cylinder measuring gauge.**
*Range:* Size I—2.17 ins. to 2.85 ins. Size II—3.54 ins. to 8.27 ins.

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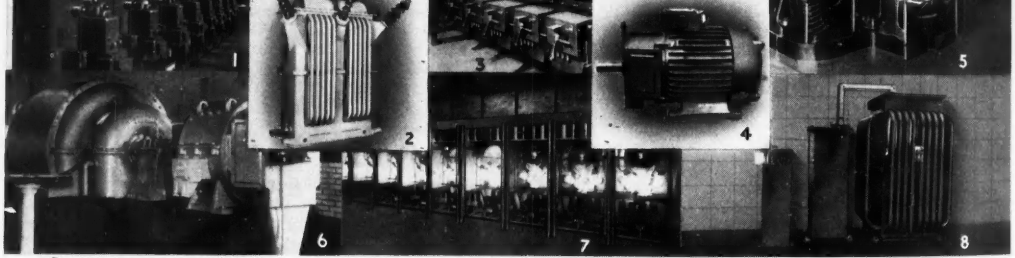

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oscillograph, and is fixed by means of a coupling flange on the engine crankshaft to be tested. The signal voltage is taken from a centrally located needle contact. The pick-up is completely enclosed in a tubular cover 95 mm long and 40 mm in diameter. The unit is sturdily constructed. It has a sensitivity of 0·001 degree and gives fully reliable results at all frequencies of vibration, even on small high-speed engines. The pre-amplifier is incorporated in the S.L.M. oscillograph unit built for use with this pick-up.

A new small-size thermocouple has also been developed by S.L.M. The hot junction is enclosed in a non-metallic tubular body which is resistant to high temperatures, scaling, and mechanical stresses. The protecting material also has a low thermal conductivity, so that the error in indication due to the heat loss from the measuring point to the walls is very small. The measuring accuracy is thus higher than that of other thermocouples of standard types and exceeds even the accuracy obtained with mercury-in-glass thermometers. The thermocouple leads are covered with an insulated flexible metal sheath for protection against mechanical injury. A moving coil type millivoltmeter with 12 thermocouple connections is used for temperature indication, the range normally covered being from 0° to 600° C. Thermocouples of this type are suitable for gas temperature measurements in the combustion chambers of gas turbines, the exhaust manifolds of diesel engines, etc.

S.L.M. have produced a small piezo-electric pressure pick-up with a high natural frequency and a practically linear response. The pressure to be measured is transmitted by a diaphragm to semi-cylindrical quartz elements situated in a thin-walled tube. The pick-up has a sensitivity of $10^{-12}$ coulomb per atmosphere and gives reliable indications of pressures from 0·1 to 200 atm. (1·42 to 2840 psig). Special units have been designed for even higher pressures. The pick-up can be calibrated statically and frequent recalibration is not required. Owing to the special materials used in its construction, the pick-up can be employed at temperatures of 100-200° C (212-392° F). For higher temperatures, such as those occurring in the exhaust pipes of internal combustion engines, a special water-cooled arrangement can be provided. The signal voltage is fed into an oscillograph unit with a patented degenerative feedback giving a high input impedance and ensuring a high degree of stability in the amplification stage.

The ATELIERS DE SÉCHERON, of Geneva, are making single-phase three-winding transformers which are combined to form a three-phase group for 60,000 kVA with a ratio of 160,400 ± 14 × 2,695/135,000/12,650 volts. These transformers are set up in a network with a rigidly earthed neutral point and can therefore be made with gradual insulation. In the field of automatic controls, a new version of the REX-V type controller unit has been produced.

Improved electrodes for steel welding now produce welds with a U.T.S. of about 80 tsi associated with good elongation and notch sensitivity characteristics.

A micrometer capable of measuring accurately 0·001 millimetre over a range from zero to 25 mm has been developed by TESA, S. A., of Renans-Lausanne. Known as the "Micromaster," this micrometer, Fig. 10, avoids parallax errors by transferring the vernier scale from the thimble to the sleeve, thus allowing the graduations to be side by side at the same level. Hundredths of a millimetre can be observed through a window and thousandths can be read off the vernier scale while the number of millimetres is shown on the barrel. The "Micromaster" has the dimensions of a normal micrometer and is just as simple to use. To avoid errors due to deformation of the guide thread during adjustment, the micrometer screw is not of the split type. A version with a non-rotating micrometer screw and a pedestal mounting is available for measurements on very small components.

TESA have also developed a new direct-reading hygrometer indicating relative humidity with an accuracy of ± 1 per cent at temperatures between 0° and 45° C. The apparatus requires no external connections and is insensitive to large variations in the composition of the air. Its operation is based on the differential diffusion of gases through a porous diaphragm. The pressure indicated by a manometer connected to a container filled with liquid and covered with a porous membrane decreases with increasing humidity of the outside air. The reverse occurs if the container is filled with a drying substance, such as silica gel. The phenomenon is accurately reproducible. The relationship between relative humidity and pressure, obtained after compensating by mechanical means for the effect of temperature, is used in this hygrometer. A considerable increase in differential pressure has been obtained by using a new finely porous product which is not hygroscopic. The degree of humidity is determined from the height of the liquid in the manometer and from a family of curves inscribed on a rotating cylinder, temperature compensation being obtained automatically as a result of the rotation of the cylinder which is connected to a bi-metal spiral spring. The apparatus can be used for meteorological work and air-conditioning, as well as in the textile, tobacco and food processing industries.

The "Elop Hydrotester" for absolute humidity measurements, has been developed by ALBERT MARK, of Zurich. The apparatus comprises a capacitance bridge which measures the moisture content, using the dielectric constant of water as a basis. The material to be tested serves as a dielectric in another branch of the bridge. The measuring electrodes are 20 cm wide and up to 90 cm long, and can be set up at any distance from the apparatus. The high sensitivity of the instrument makes it possible to effect measurements on material weighing as little as 10 g per m². Voltage stabilisation is provided and a warning device with red and green lights for visual indication of maximum and minimum humidity limits enables a high accuracy to be maintained in humidity control. The apparatus is particularly designed for the textile, synthetic fibre and paper making industries. It can also be used in conjunction with automatic recorders and servomotor control units.

Fig. 10

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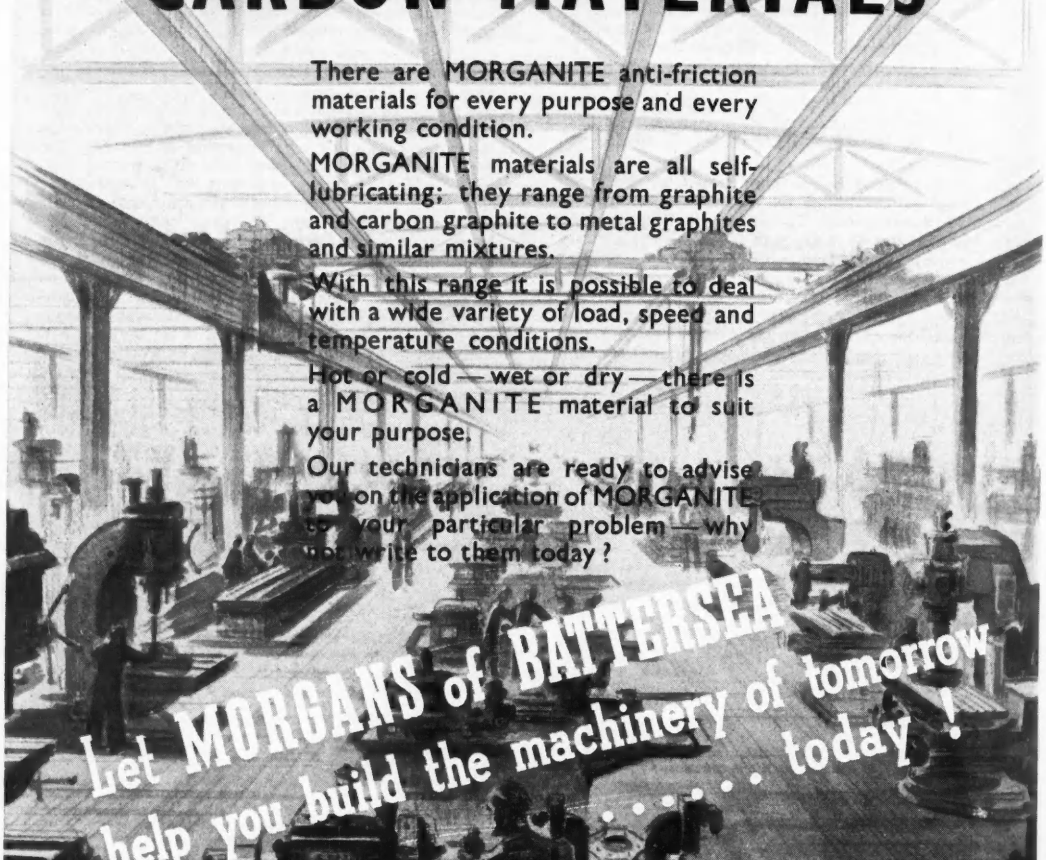


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# THE PHYSICAL SOCIETY EXHIBITION

*The 36th PHYSICAL SOCIETY EXHIBITION held at Imperial College, London, from April 3rd to April 8th, 1952, covered a wide range of scientific and technical instruments and apparatus. The rule that no instrument may be shown more than three times ensures that only recent developments were exhibited. In the following, necessarily brief, review, novel features are described, and an attempt is made to point out exhibits which are primarily interesting from the point of view of their industrial applications.*

## INDUSTRIAL EQUIPMENT

An instrument for continuously measuring the variations in diameter of machine-drawn glass tubing has been developed by the GENERAL ELECTRIC CO. LTD. The variations in diameter cause movement of two spring-loaded rollers supported by frames which move freely in the horizontal plane and carry detector coils and an armature. The relative movement between the armature and coils is transmitted as an out-of-balance current to a bridge coupled to a magnetic amplifier and a recording instrument.

A crack detector with a controllable permanent magnet requiring no external supplies and suitable for specimens up to 18 in. long has been produced by the METROPOLITAN-VICKERS ELECTRICAL CO. LTD. The apparatus can also be used for two-directional crack detection in conjunction with current flow magnetising. METROPOLITAN-VICKERS have also developed a piezo-electric rotational accelerometer of the inertia type, for the study of irregularities in the motion of rotating parts, particularly those due to errors in the profile and pitch of gear teeth. The new light-weight Metropolitan-Vickers " Metroflux " magnetic sorting bridge, type MMS4, serves to detect differences in composition and condition of apparently similar steel parts. Indication is by means of a vibration galvanometer or by an oscilloscope.

A new portable engine indicator for the measurement of fuel or gas pressures, valve lift, etc., was shown by the Thornton Research Centre of the SHELL REFINING & MARKETING CO. LTD. The crank-angle position of any point on the oscilloscope screen diagram can be determined stroboscopically. A portable stroboscopic lamp is used to illuminate a point on a scale marked, for instance, on the flywheel rim, and a voltage pulse from the stroboscope unit is simultaneously fed into the amplifier which identifies the corresponding point on the diagram by a momentary vertical deflection. The equipment can be either battery- or mains-operated.

The new STANDARD TELEPHONES & CABLES engine indicator for the measurement of torsional vibration, cylinder and fuel line pressures, etc., has been developed in collaboration with the research laboratories of the ANGLO-IRANIAN OIL CO. LTD. Integrated and rate-of-change diagrams are indicated on an oscilloscope screen, and the entire unit operates from a 12-volt battery.

NEWTON & CO. LTD. showed their industrial profile projector for checking the form and dimensional accuracy of small component parts. The magnified image is projected on to a mirror which reflects it on to a viewing screen with two plass plates, between which a transluscent sheet with a suitably enlarged outline of the workpiece is inserted.

A miniature layer thickness meter for the measurement of non-ferrous strip or foil is shown by SALFORD ELECTRICAL INSTRUMENTS, LTD. The strip is placed between the base and the ball foot of the instrument.

The CHEMICAL DEFENCE ESTABLISHMENT demonstrated a photo-electric counter for particles in dilute aerosols, capable of counting particles in concentrations of up to 2,000 per litre, over the size range from 1 to 10 microns diameter.

The BRITISH THOMSON-HOUSTON CO. showed a waterproof ¼ hp motor running under water. The stator is completely insulated against ingress of water with the aid of a modified polyester resin. By means of casting and impregnating operations, a solid additional resin sheath is provided on the end windings of the coils. This insulation has been particularly developed for stator units to be used in machine tools.

The high-temperature high-vacuum furnace, produced by the GENERAL ELECTRIC CO. LTD., employs a graphite element and holds a cylindrical charge of about 6 cm length and 5 cm diameter. The furnace is mounted on a 3000 litre/sec pump. A temperature of 2000° C, corresponding to a power input of only a few kilowatts, can be reached in a few minutes.

A high-velocity streak camera, designed for the study of explosive phenomena, which can operate at ranges of from 10-30 ft, was shown by the ARMAMENT RESEARCH ESTABLISHMENT. The maximum writing speed is 1·6 mm per microsecond, giving a time resolution of at least 0·1 microsecond.

## ELECTRONIC TEST METERS

The " Electronic Multimeter " CT.38 designed by the AUTOMATIC COIL WINDER & ELECTRICAL EQUIPMENT CO. LTD. can be used for both radar and electronic work. The instrument has 98 ranges, with f.s.d. current ranges from 25 $\mu$A to 25 A, and f.s.d. voltage ranges from 250 mV to 10,000 V, for d.c., a.c. and low radio-frequencies. Radio-frequencies up to 250 Mc/s are covered with a diode head used externally.

The Blind Man's AvoMeter, produced by A.C.W. & E.E., has a scale plate with figures marked in Braille and an external electrical pointer. The pointer is clamped in the measuring position by means of an internal feeler arrangement.

The new power factor and wattage meter developed by AUTOMATIC COIL WINDER & ELECTRICAL EQUIPMENT CO. LTD. is for use with a standard AvoMeter. The instrument measures the current flowing in the circuit under test and then neutralises its power component (for single-phase) or its reactive component (for balanced two- or three-phase circuits). The power factor and wattage are determined with simple calculators from the ratio of the two readings.

W. G. PYE & CO. LTD. showed a new automatic self-balancing potentiometer and pH-meter. The accuracy is equal to that of a manually balanced potentiometer instrument, and the pH value is indicated directly by a four-figure counter. A PYE direct-reading pH-meter with exceptional freedom from zero drift is also exhibited. The response is linear to 0·1 per cent. The novel electrode unit is fitted in a protective polythene sheath with a platinum winding for automatic temperature compensation.

A new voltage comparator was exhibited by W. G. PYE & CO. LTD. In this precision instrument, the two voltage sources are connected to the fixed poles of a " break-before-make " type switch, and the moving contacts are alternately connected by a condenser to a valve amplifier. The difference voltage is zero when equal voltages are obtained.

A prototype of a portable fluxmeter was shown by SALFORD ELECTRICAL INSTRUMENTS LTD. This moving-coil instrument, used with a search coil in a magnetic field, gives a deflection corresponding to the flux linkages. The instrument has a 6-in. scale and 60-0-60 division markings, one division corresponding to 10,000 flux linkages.

The double-beam oscillograph produced by A. C. COSSOR LTD. showed two independent traces simultaneously on a 90 mm flat screen. The instrument is particularly designed for the study of transients and low-frequency phenomena. It can be used in conjunction with their 35 mm camera for photographic recording, and the Cossor d.c. pre-amplifier unit, model 1430.

The AIRMEC 20-kV portable ionisation tester, type 755, comprises a control unit with indicators and L.T. power supplies, and an H.T. unit connected to the former by means of a multicore flexible cable so that it can be used in a cage or remote from the operator. Indication is both by loudspeaker and meter.

A magnetic oxygen meter is being produced by the BRITISH OXYGEN CO. LTD. as a portable instrument, primarily intended for use in hospitals. The meter comprises a miniature-size glass dumb-bell suspended by means of a quartz fibre in a non-uniform magnetic field. If the surrounding air contains oxygen, it has a higher susceptibility than the dumb-bell, which therefore rotates towards a direction of lower field strength. The rotation is indicated by a light beam reflected by a mirror 1 mm square cemented on the dumb-bell.

A potentiometric oxygen meter produced by BRITISH OXYGEN was also shown. The cell contains a dropping mercury electrode immersed in a solution of potassium chloride, and a silver-silver chloride electrode is used as the anode. The gas to be analysed passes through the cell and the diffusion current of any oxygen in the solution changes the electrode potential, which is measured on a pH-meter. An oxygen purity meter, also developed by BRITISH OXYGEN, measures the amount of argon impurity in oxygen. The bridge has four Cambridge thermal conductivity cells, two being in the test gas and two in a reference gas. The meter has thermostatic temperature control and voltage and frequency compensation.

## CHRONOSCOPES, COUNTERS, COMPUTERS

The AIRMEC LABORATORIES industrial electronic counter, type 851, operating with a photocell unit, has up to three electronic dividing circuits, which can divide by 10, 12, or 16. Their counting rate is about 2000 per second. The output is fed to a six-figure electromechanical counter. Another AIRMEC counter is the batch counter, type 808, which counts any predetermined number of batches between 1 and 225, with dividing units determining batches of 10, 100, 12 and 144.

The AIRMEC time interval meter, type 771, measures short time intervals from 0·01 sec. to 60 sec. Integration of a number of short time pulses can be made over a long period.

The microsecond counter chronometer produced by CINEMA TELEVISION LTD. can measure time in the range of 1 microsec. to 1 sec. in steps of 1 microsec. This pulse type apparatus comprises two crystal-controlled oscillators, an electronic gate, and six decade counters.

STANDARD TELEPHONES & CABLES LTD. showed a high-speed electronic device with three decade counters for revolution counting and batch selection, which can handle pulses at rates varying from 1 to 5000 per second. The output can also be used to control electro-mechanical devices. A Standard Telephones test routiner set, designed for laboratory testing of decade counters, performs 25 different tests on each of ten cathodes in 1½ minutes. A fault on any of the tests causes an alarm lamp to light. The tests are carried out at 5 kc/sec.

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## AUTOMATIC CONTROL EQUIPMENT

Typical applications of the "Teddington" Series ZA electric portioning equipment were shown by the BRITISH THERMOSTAT CO. LTD. The modified Wheatstone bridge circuit provides remote portioning control of hydraulic valves and power units, and the equipment includes temperature, pressure, liquid level and humidity-sensitive elements. A reversing motor with a very high ratio gear box provides the operating torque acting on a drive shaft which is fitted with a sliding crank for valve operation, or with a crank arm for the operation of dampers or other rotary elements. The other end of the drive operates a balancing potentiometer.

The PLESSEY CO. LTD. showed a Nyquist diagram plotter which records the phase and amplitude response of servomechanisms. The oscillator frequency can be swept automatically from 1600 cps down to 0·16 cps, these being maximum limits. The response in the form of a Nyquist diagram is recorded on a polar chart.

A high-speed cathode-ray oscillograph with a 0·2 microsecond time base, used in conjunction with a pulse generator in test gear for millimicrosecond pulse circuits, was exhibited by the ATOMIC ENERGY RESEARCH ESTABLISHMENT.

## PICK-UPS, TRANSDUCERS, STRAIN GAUGES

The BRITISH THERMOSTAT seamless metallic bellows made with simple, double, triple or quadruple walls are employed as power elements in thermostats and instruments operated by fluid pressure, as well as in packless glands, shaft seals and flexible couplings.

The BRITISH THERMOSTAT resistance-wire strain gauges were shown in single or multiple forms, with lengths varying between 0·062 in. and 2·0 in. and resistance values from 50 to 2500 ohms.

Electrostrictive and piezo-electric pick-ups made of barium titanate micro-crystalline ceramics are being produced by the PLESSEY CO. LTD. The untreated ceramics show electrostrictive effects, i.e., a change in dimensions, under the influence of an electric field. Certain compositions can be permanently polarised so as to have a permanent internal static field, and these latter materials behave similarly to piezo-electric crystals.

A new electro-mechanical converter instrument, produced by SALFORD ELECTRICAL INSTRUMENTS LTD., gives remote indication of gas or hydraulic pressure, etc. The measured quantity is converted into a displacement which is applied to the transmitter unit and varies its mutual inductance.

## COMPONENTS AND ACCESSORIES

The BRITISH ELECTRIC RESISTANCE CO. LTD. showed a range of resistors with a ceramic body which sets hard at 150° C and yet is unaffected by temperatures as high as 400° C. This enables wires made from high-resistivity alloys, which do not withstand the high firing temperatures of enamel, to be wound at a close pitch, thus obtaining very high ohmic values. The ceramic material provides adequate insulation resistance and dielectric strength. The "Bercostat" high-accuracy rotary rheostats, also produced by this firm, are embedded in vitreous enamel. They are of smaller dimensions than any other rheostats of this type made in this country.

Permalloy "F," a new magnetic material characterised by a rectangular hysteresis loop and high permeability at relatively low field strengths, is used in toroidally-wound saturable-core reactors and in magnetic amplifiers produced by STANDARD TELEPHONES & CABLES LTD.

An experimental amplifier utilising germanium crystal triodes is shown by Standard Telephones & Cables. If this amplifier were used in a broadcast receiver, loudspeaker reception would be obtained without the use of a mains supply or filament heating battery. Standard Telephones also exhibited a range of germanium crystal diodes for radio equipment and other electronic applications.

New iron micropowder magnets, made by a new moulding method, are manufactured by SALFORD ELECTRICAL INSTRUMENTS, LTD. The magnets have an energy factor in the range of 0·5 to $1 \times 10^6$ gauss-oersted; they are mechanically strong and corrosion-resistant and have a very high specific resistance.

BRITISH THOMSON-HOUSTON CO. LTD. demonstrated a light beam apparatus for the measurement of fine atmosphere dust in industrial premises, such as steel and iron foundries. The apparatus uses a high-pressure mercury-vapour lamp and has a photoelectric device for quantitative measurement of dust densities.

The Flood-Hilger point source hydrogen lamp, produced by HILGER & WATTS LTD., provides a source of a continuous ultra-violet spectrum. Constant output can be maintained by a specially designed control unit.

The TELEGRAPH CONSTRUCTION & MAINTENANCE CO. LTD. showed a variety of alloys and materials, such as Telconel (electrical resistance alloy), aluminium-clad iron, H.C.R. and Radiometal magnetic alloys, magnetic materials in the form of thin strip, and malleable hard magnetic alloys.

## X-RAY EQUIPMENT

An Ehrenberg-Spear micro-focus X-ray tube was exhibited by HILGER & WATTS LTD. The unit, including the all-metal demountable tube, exciting and control gear, is suitable for use with small diffraction cameras or for micro-radiography.

The PLESSEY CO. LTD. exhibited their 19 cm high-temperature X-ray camera, with a platinum-rhodium wound furnace for use at temperatures up to 1500° C. The water-cooled body can be either evacuated or fitted with an inert gas. A room-temperature X-ray camera taking either a 75 mm or a 150 mm-diameter film ring is also shown by the Plessey Co. The smaller ring is primarily designed for taking rapid glancing-angle photographs, whereas the larger ring is for more precise photographs of powder or glancing-angle specimens. In both models, provision is made for rotation or oscillation of the specimen.

## MICROSCOPES AND ELECTRON MICROSCOPES

NEWTON & CO. LTD. showed their long working distance microscope attachment, by means of which an image of unity magnification is formed by a concave mirror, for viewing by a conventional microscope.

A number of types of electron microscopes have been developed by the METROPOLITAN-VICKERS ELECTRICAL CO. LTD., and a selection of photo-micrographs were shown to illustrate the improved penetration obtained at higher voltages over the range 25-100 kV.

AVIMO LTD. exhibited the Aviscope, an instrument which can be used to examine living cellular structures with higher magnifications than have hitherto been possible with the normal optical microscope. The complete instrument includes a flying spot scanning generator with a short-persistent fine-focus oscilloscope, two optical microscopes, a precision slide stage, a photomultiplier tube unit, a wide-band electronic amplifier, a nine-inch screen tube of the magnetically deflected type, and various co-ordinating circuits, mixers, oscillators and generators. The limits of magnification depend upon the lines per field. Remote viewing units may be connected, with a corresponding increase in the viewing audience.

## SPECTROMETERS

The HILGER & WATTS recording X-ray spectrometer, driven by a synchronous motor and a four-speed gear box, is suitable for quantitative powder analysis, studies of texture and the exact measurement of lattice parameter. Angle markings on the recorder charge are produced by electronic pulses. The goniometer radius is adjustable between 150 mm and 200 mm. The Geiger-Müller tube has a range of —10° to 175° which can be exceeded when a monochromatising crystal is employed, and reading accuracy is 15 sec. of arc. High order resolution enables the $K\alpha$ doublet to be resolved at low $\theta$ values.

A pen-recording spectrograph scanner, produced by HILGER & WATTS for the direct recording of absorption spectra, includes a motor-driven slit and mirror assembly, and a well stabilised d.c. amplifier. A number of new accessories has been designed for use with the HILGER & WATTS Uvispek spectrophotometer, viz.: a diffused reflection attachment with photocell and standard white surface for comparison; a fluorescence attachment; and a flame photometer attachment.

## PARTICLE ACCELERATORS

The METROPOLITAN-VICKERS Company's display of charged particle accelerator equipment included glass and cast porcelain doughnuts, and a photo-projection system for the analysis of Wilson cloud-chamber photographs. Components were also shown of a 10 MeV linear accelerator under construction.

Linear accelerator components, including corrugated waveguides and their feed systems, were shown by the ATOMIC ENERGY RESEARCH ESTABLISHMENT.

## BOOKS

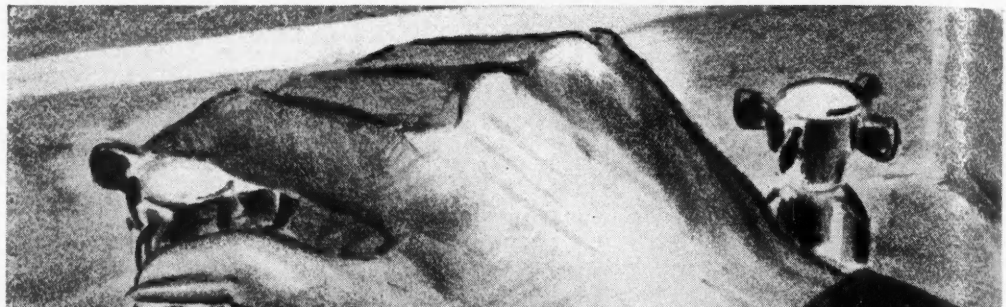
CHAPMAN & HALL LTD. exhibited a number of publications, some of which are indicated in the following list.

*Encyclopedia on Cathode-Ray Oscilloscopes and their Uses.* Compiled by J. F. Rider and S. D. Uslan.
*Theory and Design of Valve Oscillators.* By H. A. Thomas.
*Industrial Applications of Gas-filled Triodes (Thyratrons).* By R. C. Walker.
*Fundamentals of Automatic Control.* By G. H. Farrington.
*Laboratory Instruments: Their Design and Application.* By A. H. Elliot and J. Home Dickson.
*Rockets, Missiles and Space Travel.* By W. Ley.
*The Science of Flames and Furnaces.* By M. W. Thring.
*The Welding of Non-ferrous Metals.* By E. G. West.
*Sound Insulation and Room Acoustics.* By P. V. Bruel.
*Experimental Spectroscopy.* By R. A. Sawyer.
*Adhesives for Wood.* By R. A. C. Knight.

The above titles are Chapman & Hall publications and none of the books published by their American associates, John Wiley & Sons, Inc., and Reinhold Publishing Corporation, Inc., some of which were exhibited, are included in this list.

SIR ISAAC PITMAN & SONS LTD. exhibited a wide variety of technical books, a selection of which is given below.

*AC/DC Test Meters.* By W. H. Cazaly and T. Roddam.
*Transformers.* By F. C. Connelly.
*Cathode-Ray Oscillographs.* By J. H. Reyner.
*Industrial High Vacuum.* By J. R. Davy.
*Fractional H.P. Electric Motors.* By F. G. Spreadbury.
*Displacement Pumps and Motors.* By R. Hadekel.
*Quantum Mechanics.* By A. Landé.
*Aerodynamics of Supersonic Flight.* By A. Pope.



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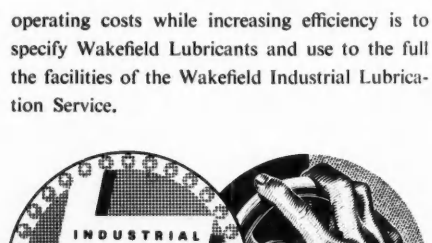


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# NEWS OF THE MONTH

## PERSONAL

**Mr. Ernest Belcher,** sales manager, and **Mr. J. B. Samson, M.I.Mech.E., M.I.Prod.E., A.R.Ae.S.,** have been elected directors of Ransome and Marles Bearing Co. Ltd., Newark-on-Trent.

**Mr. H. F. Bibby, B.Sc.Tech., A.M.I.E.E., A.M.I.Mech.E.,** has been appointed manager of the American Division of Metropolitan-Vickers Electrical Export Co. Ltd., London.

**Dr. B. K. Blount, F.R.I.C.,** director of scientific intelligence in the Ministry of Defence, has been appointed deputy secretary in the Department of Scientific and Industrial Research.

**Mr. Gordon Eyre,** London sales manager of Monks & Crane Ltd., Birmingham, has been appointed general sales manager of the Company. **Mr. P. A. H. Luttrell** has been appointed London sales manager. **Mr. W. Duckett** has been appointed Northern area manager at the Manchester office of the Company.

**Mr. Roger Falk, O.B.E.,** has joined Production Engineering Ltd., to take charge of their marketing organisation.

**Mr. William Frost** has been appointed representative of Macrome Ltd. for South Lancashire to succeed **Mr. S. Procter** who is no longer with the company. **Mr. J. Bradley** has been appointed representative for North Lancashire.

**Mr. W. M. B. Furniss,** chairman of the Electric Construction Co. Ltd., Wolverhampton, has been appointed a member of the Midland Regional Board for Industry.

**Mr. R. M. Grant, B.Sc., M.I.E.E.,** has been appointed assistant manager of the Plant Sales Department of the British Thomson-Houston Co. Ltd., Rugby.

**Dr. P. E. Hammarlund,** chief design engineer of Asea Electric Ltd. and Fuller Electrical & Mfg. Co. Ltd., Fulbourne Road, London, E.17, has taken up a senior appointment with the Asea AB., Västeras, Sweden. **Mr. A. J. Haselfoot,** manager of the power department of Asea, has been appointed chief design engineer.

**Mr. W. H. Hodgetts,** production manager of Imperial Chemical Industries Ltd., Witton, Birmingham, has been elected chairman of the Birmingham District Advisory Committee for the Midland Regional Board for Industry, in succession to **Mr. J. A. Hunt,** general manager of Hymatic Engineering Co. Ltd., Redditch.

**Mr. J. A. Hunt, M.B.E.,** general manager of The Hymatic Engineering Co. Ltd., has been elected President of the British Compressed Air Society. **Mr. H. G. Harwood,** director of Hugh Wood & Co. Ltd., has been elected Vice-President.

**Mr. Fredk. H. Johnson,** local director of Thomas Smith & Sons (Rodley) Ltd., has been appointed a full director of the Company which is a member of the Thos. W. Ward Group of Companies.

**Vice-Admiral Eric Longley-Cook** has been appointed managing director of the Fairfield Shipbuilding and Engineering Co. Ltd., Glasgow.

**Mr. A. W. Manser, B.Sc., A.M.I.Mech.E., M.I.Loco.E.,** has been appointed chief mechanical engineer (railways) of the London Transport Executive.

**Mr. H. J. Nixon** has been appointed works director of Alvis Ltd., Holyhead Road, Coventry.

**Mr. A. E. Peatfield, A.M.I.Mech.E., A.M.I.Struct.E.,** has been appointed standards engineer of the Anglo-Iranian Oil Co. Ltd.

**Mr. G. R. Roberts,** chief engineer, and **Mr. C. G. Rye,** secretary, have been appointed directors of Bowater's Lloyd Pulp and Paper Mills Ltd., Bowater's Mersey Paper Mills Ltd., and Bowater's Thames Paper Mills Ltd. **Mr. H. M. Archibald,** manager of the Sittingbourne Mills of Bowater's Lloyd Pulp and Paper Mills Ltd., has been appointed a director of that company.

**Mr. H. F. Sherborne, M.C., M.A.(Oxon), A.Inst.N.A., M.Inst.M.,** director of the Yorkshire Copper Works Ltd., Leeds, has been appointed general manager of the Company.

**Mr. W. R. Verdon Smith** and **Mr. G. S. M. White** have been appointed managing directors of the Bristol Aeroplane Co. Ltd. **Sir G. Stanley White, Bt.,** who relinquished his position of managing director, has been elected deputy chairman of the company.

**Sir Henry Tizard, G.C.B., A.F.C., F.R.Ae.S., F.R.S.,** retired from the position of chairman of the Defence Research Policy Committee. His successor is **Sir John Cockroft, F.R.S.,** who will continue to serve as director of the Atomic Energy Research Establishment.

**Mr. W. M. Tribute** has been appointed export advertising manager, **Mr. H. K. Squires,** home advertising manager, and **Mr. G. J. Hemmings,** continental sales manager, of Hoover Ltd.

**Mr. P. Woodward** has been appointed publicity manager, and Mr. J. S. Exley, continental representative, of Richard Sutcliffe Ltd., Horbury, Wakefield, Yorkshire.

## ROYAL ORDNANCE FACTORIES BOARD

As announced by the Minister of Supply, Mr. Duncan Sandys, a Royal Ordnance Factories Board has been established which will be responsible for advising him on matters of policy in relation to the Royal Ordnance Factories.

The Chairman of the new Board will be the Ministry of Supply's Controller of Supplies (Munitions), Lieutenant-General Sir Kenneth N. Crawford, K.C.B., M.C. He will have as his Deputy Mr. C. K. F. Hague, Deputy Chairman and Managing Director of Babcock & Wilcox Ltd., who is resigning from the Minister's Engineering Advisory Council on appointment to the Board.

There will be two other non-official members, Mr. Henry A. Benson, C.B.E., F.C.A., of Cooper Brothers & Co., Chartered Accountants, London, and Dr. James Taylor of I.C.I. Ltd. The non-official members of the Board will serve in an honorary capacity.

The official members of the Board, in addition to the Chairman, will be Sir Lewis B. Hutchinson, K.B.E., C.B., Deputy Secretary, Ministry of Supply; Mr. A. G. E. Briggs, Deputy Controller of Supplies (Munitions Production); Mr. N. Baliol Scott, Director of Organisation and Methods, and Mr. T. E. Harris, C.B., C.B.E., Director General of the Royal Ordnance Factories.

## BUSINESS NOTES

**Temple Instruments Ltd.** have built a new works at Sharrocks Street, Wolverhampton.

**D. Napier & Son Ltd.** have purchased factory and plant of British Salmson Aero Engines Ltd., Raynes Park, London, S.W.10, in order to expand manufacturing facilities for the development of new types of aero and marine engines.

**The Alpema Agricultural Machinery Development Co. Ltd.,** Redhill Aerodrome, Surrey, has been formed to specialise in the production of agricultural machinery for small farms. Mr. Alan B. Fraser is managing director, and Mr. Marcus Langley, A.M.I.Mech.E., technical director.

A new Government factory at Coleraine, Northern Ireland, has been leased to **Lodge Plugs Ltd.,** Rugby. It will be used for the production of sparking plugs.


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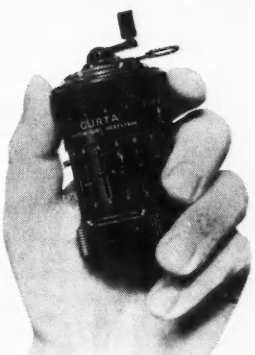


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## SIG CAM MILLING MACHINE, TYPE HRF 500

An entirely new hydraulic milling machine for the production of plate cams and cylindrical cams is now being produced by the Swiss Industrial Company of Neuhausen and is known as the HRF 500. It was designed with the following aims: accurate reproduction of the master template, utilisation of simple sheet templates, well finished milled surfaces and the use of sintered carbide cutters.

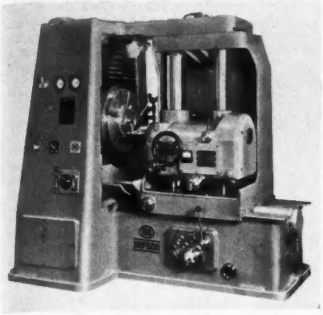

Fig. 1

The first objective was achieved by reducing the number of intermediate parts to a minimum through mounting the template on the workpiece arbor. A very sensitive light hydraulic copying device, using low driving power, permits the use of sheet templates. Extreme accuracy and good finish of the milled surface are ensured by the overall rigidity of the machine, heavy precision bearings and the automatic feed regulator which maintains constant feed according to the radius and slope of the cam. The machine (Fig. 1) has a strongly constructed bed containing the hydraulic and electrical equipment as well as oil and coolant installations. The portal type frame on the left-hand side supports the work head and the copying device. The frame on the right-hand side carries the milling-head, which is vertically adjustable on two stiff columns. The whole framework is locked during cutting for maximum rigidity. The vertically adjustable workhead is supported by a piston and has a steplessly adjustable rotational speed of 0·016 to 0·3 rpm. The hydraulic copying device uses a roller of the same diameter as the milling cutter and this transmits the motion by a lever. A second cam is used for the constant feed device. This is essential when milling steep cams to compensate for the additional feed due to the vertical displacement of the workhead. The powerful milling-head drive has twelve speeds ranging from 100 to 1000 rpm. The hydraulic feed has a rapid approach to the work followed by a machining feed to a fixed stop. After reaching the fixed stop, the automatic locking of the whole framework is put into operation. The clamping of the milling head on the columns, of the quill in the head, and of the crosshead, is also hydraulic.

Cylindrical cams can be machined using a special attachment. (Fig. 2). The master templates, even for this type of cam, are flat thin sheets, which are much more economical to produce than normal drum templates.

Very high feeds can be used on this rigid machine, resulting in low floor-to-floor times. For instance, cams 1·6 ins. wide and 0·8 in. deep can be rough milled in cast iron having a hardness of 250 B.H.N. using a feed of 2·4 ins. per minute. Carbide cutters can safely be used, allowing a doubling of normal feeds, so reducing machining times by 50%. The machine has automatic lubrication and centrally placed controls. The latter feature, together with hydraulic clamping, facilitate operation, and, as the human element is reduced to a minimum, the machine can be served by relatively unskilled operators. The setting times are short and a complete change-over of template, tracer, milling cutter and headstock change gears can be accomplished in 15 minutes.

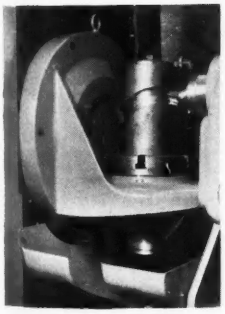

Fig. 2

The following specifications give an indication of the machine's capacity: Faceplate diameter 19⅝ ins., maximum diameter for plate cams 23⅝ ins., maximum diameter for cylindrical cams 9¾ ins., maximum height of cylindrical cams 11⅝ ins., milling head motor power 5 hp.

## VERTICALLY MOUNTED TYPE F/VM STRATELINE GEARS

Varatio-Strateline Gears Ltd., 278 Aberdeen Avenue, Trading Estate, Slough, have introduced a modified version of their Strateline Speed Reducer for vertical flange mounting. This unit is designed for attachment to mixing machines and agitators of all types. It has a reduction of 33 : 1, and incorporates a 7½ hp motor running at 950 rpm with a torque output of 13,000 lbs. ins. At a later date it is intended to introduce vertical flange mounted units to cover the whole of the firm's normal range of boxes, including


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double stage units which will enable torques of up to 30,000 lbs. ins. to be handled.

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## NEW ALLOYS AID GAS TURBINE PERFORMANCE

The Birmingham research laboratories of The Mond Nickel Co., which early in the war years produced Nimonic, the nickel-chromium alloy which really turned the gas turbine from an expensive prototype to a production power unit, have now announced a new advance. Ever since the development of the earliest Nimonic alloys for rotor blades, this laboratory has been working steadily to provide improved alloys to give better stress properties at increasing temperatures, with such success that every British aircraft gas turbine in production is fitted with rotor blades made of one or other of the Nimonic alloys.

Latest achievement is the development of Nimonic 95. This alloy is the result of intensive research which has continued for more than twelve years to improve the high-temperature properties of the nickel-chromium alloys without sacrificing forgeability at the expense of high-temperature strength. Improved methods of manufacture and processing have been adopted so that, although this new material is stronger and stiffer than Nimonic 90, it can still be hot-worked and machined.

Nimonic 95 has an increased content of hardening elements. It provides the same level of strength as Nimonic 90, but at operating temperatures some 50° C higher.

The new alloy is already in production in the works of Henry Wiggin & Co. Ltd. and will soon be available in quantity.

## NEW SEQUENCE VALVE

A special pneumatic valve for controlling the sequence of operations involved in retracting and subsequently lowering an aircraft's undercarriage has recently been designed by the Aircraft Division of The Hymatic Engineering Co. Ltd., Redditch, Worcs.

When the pilot of an aircraft fitted with this automatic sequence valve operates the " undercarriage down " control, the valve sets in motion the following series of events ; first, the undercarriage doors open ; then, just as this ram stroke is completed, it opens a lock, releasing the leg and allowing the undercarriage ram to lower the wheel. This movement completed, the valve clicks over mechanically, the doors shut around the leg and at the same time the valve is positioned for the next undercarriage sequence.

On the selection of " undercarriage up," the valve controls the reverse procedure. The doors open, the wheels retract, and the doors shut.

The basic principles of the valve, which has an operating pressure of 750 psi, are simple and fool-proof. Contained in its lightweight magnesium alloy casing are four on/off valves which, when operated by the internal switching mechanism, feed shuttle valves controlling the air flow to the door actuating rams. The movement of the switching mechanism is effected by the undercarriage leg through a slotted link to a lever mounted on the central serrated spindle.

Measuring approximately 6½ in. H × 5 in. L × 2 in. W, the complete unit weighs only 1·14 lb.

## WATER-BASED AIRCRAFT OF THE FUTURE

Designers are well ahead with projects for new types of flying-boats, some of them designed for work hitherto done by landplanes, and for operations even beyond the foreseeable capabilities of landplanes. Among these designs are water-based jet bombers capable of flying as fast as sound, diesel-driven flying-boats with a duration of 35 hours, and transports weighing over 250 tons.

Details of some of these design studies have been given by Henry Knowler, Chief Designer of the Saunders-Roe company. His design studies for the future are based on tests with revolutionary types of hull-form. The tests were made with very small scale dynamic models, which were catapulted into a large water tank.

Conventional hulls have a step-up below the fuselage so that the boat can lift free of the water on take-off. Knowler says this step-up, which spoils stream-lining, will have to go. On his models, he has been testing special surfaces which give the same effect as a stepped-up hull while the boat is taking-off along the water, but which slide up into the stream-lined fuselage as soon as the boat is airborne. These retractable surfaces mean that the boat is a flying-boat on the water but, when in flight, has the stream-lined fuselage of the fighter.

Knowler plans retractable hydrofoils-aerofoils which operate under the water and lift the hull off it, and hydroskis—ski-type floats for high-speed fighters, which will completely retract in flight. The design studies mentioned by Knowler are :

(I) Ocean Patrol flying-boat : a 150,000 lb boat capable of cruising at 400 mph for a gross range of 8,000 miles or, at 200 mph for 35 hours. A possible powerplant would be the Napier *Nomad*, the new compression-ignition diesel turboprop. These patrol boats, on anti-submarine patrol, might alight at sea, and lower special detectors beneath the surface. It is now possible to design boats capable of landing safely in waves up to 9 ft high from trough to crest.

(II) Intruder Bomber : methods have been found of carrying bombs in the hull of a bomber boat, and though operating from water, it could fly in the transonic region. The project is for a pressurized swept-wing craft with two jet engines.

(III) Military Transport : " The size of the future flying-boat is virtually unlimited," states Knowler, but a limiting factor in the immediate future will probably be engine power. For this reason, the upper limit " for some time " will be about 270 tons.

(IV) Commercial Flying-boat : the *Duchess* type, with six straight jet engines, is designed to fly 1,500 miles at 450 miles-an-hour.

(V) Fighter Flying-boat : fitted with hydro-skis. The jet engine would be set above the fuselage with a pitot entry. The design has sharply swept wings and tailplanes set high on the fin.

Mr. Knowler concludes by saying that the first atomic-powered aircraft may well be a flying-boat. The reason is that for a reactor of 100 tons, an aircraft of 200 to 300 tons would be necessary. " This is a very big aircraft to contemplate as a landplane but, as a flying-boat, such a size would be acceptable without query." The cruising speed of this first atomic aircraft will probably be below the speed of sound.

## DECCA FOR SMALL AIRFIELDS

The Decca Automatic Air Navigator, now being evaluated for world-wide use, works by picking up signals from a chain of ground radio stations, built for use by ships as well as aircraft. For land areas where there are no ships and where there is insufficient air traffic to justify setting up a full chain, Decca have designed a cheaper and simpler set of ground stations called the Integrated Track Range.

The estimated cost is about one-third of the full Decca Chain. A pilot carrying the airborne Decca Navigator and flying from the Decca Chain Coverage into one of these ITR areas would still be able to check his track and his distance along it on the Navigator, though, of course, its range is not so extensive. If he carries the Flight Log map on his dashboard, his track will automatically be drawn in on it as he flies along the Range.

## NEW PIPELINE TO PUMP NICKEL ORE CONCENTRATE 7½ MILES

A 7½-mile pipeline has been completed by The International Nickel Co. of Canada Ltd., through which the bulk concentrate from 3,650,000 tons of nickel-copper ore is being pumped annually from its newly-built Creighton concentrator to its reduction plants at Copper Cliff. It is believed that never before has concentrate been carried by pipeline in such quantity over such a distance.

The system has 12 miles of trestle, at some points 65 feet high to assure a slope to and from each of the five relay pumping stations, so that the concentrate lines will be self-draining in case of power difficulties. All told, 3 million board feet of lumber and 40 miles of wooden pipe were used.

When milling 10,000 tons of nickel-copper ore a day at Creighton, approximately 1,800 tons of concentrate and 8,200 tons of tailing are produced. Water added to the concentrate makes a pulp which flows through the pipeline at a rate of 800 gallons per minute. The tailing pulp flows at the rate of 2,500 gallons per minute.


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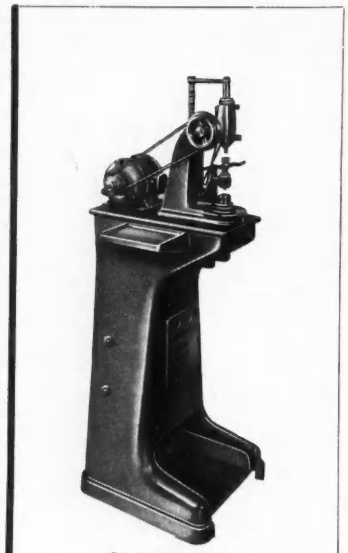

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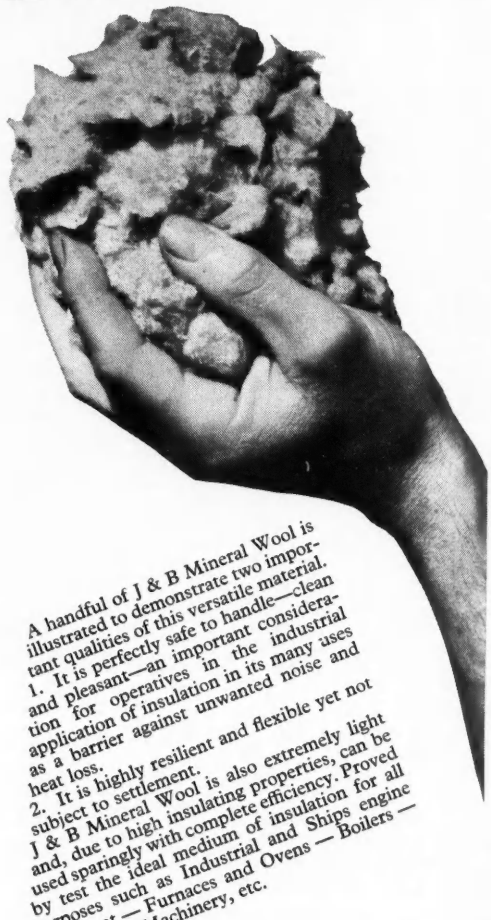

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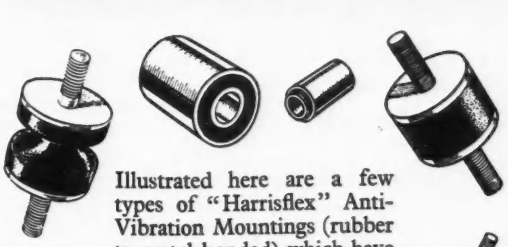

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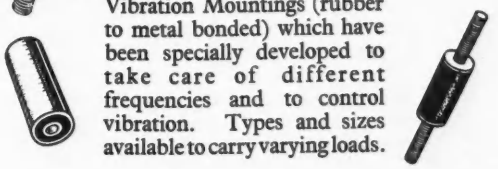

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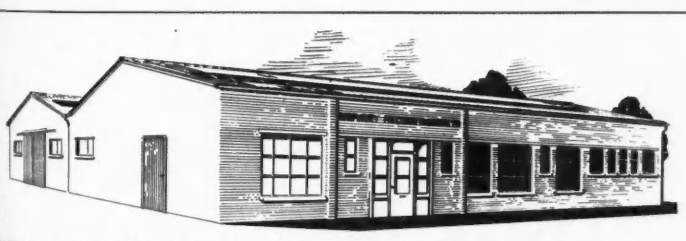

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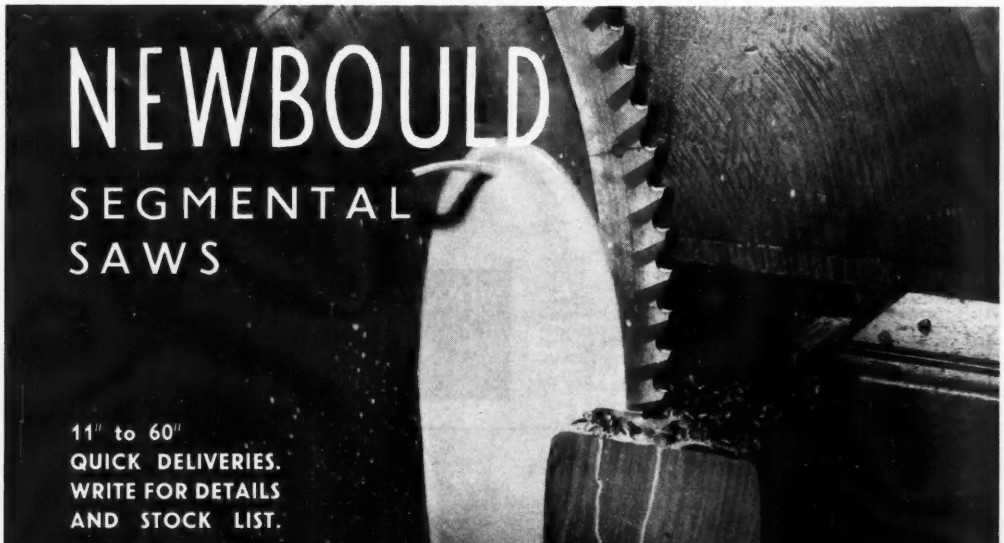
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